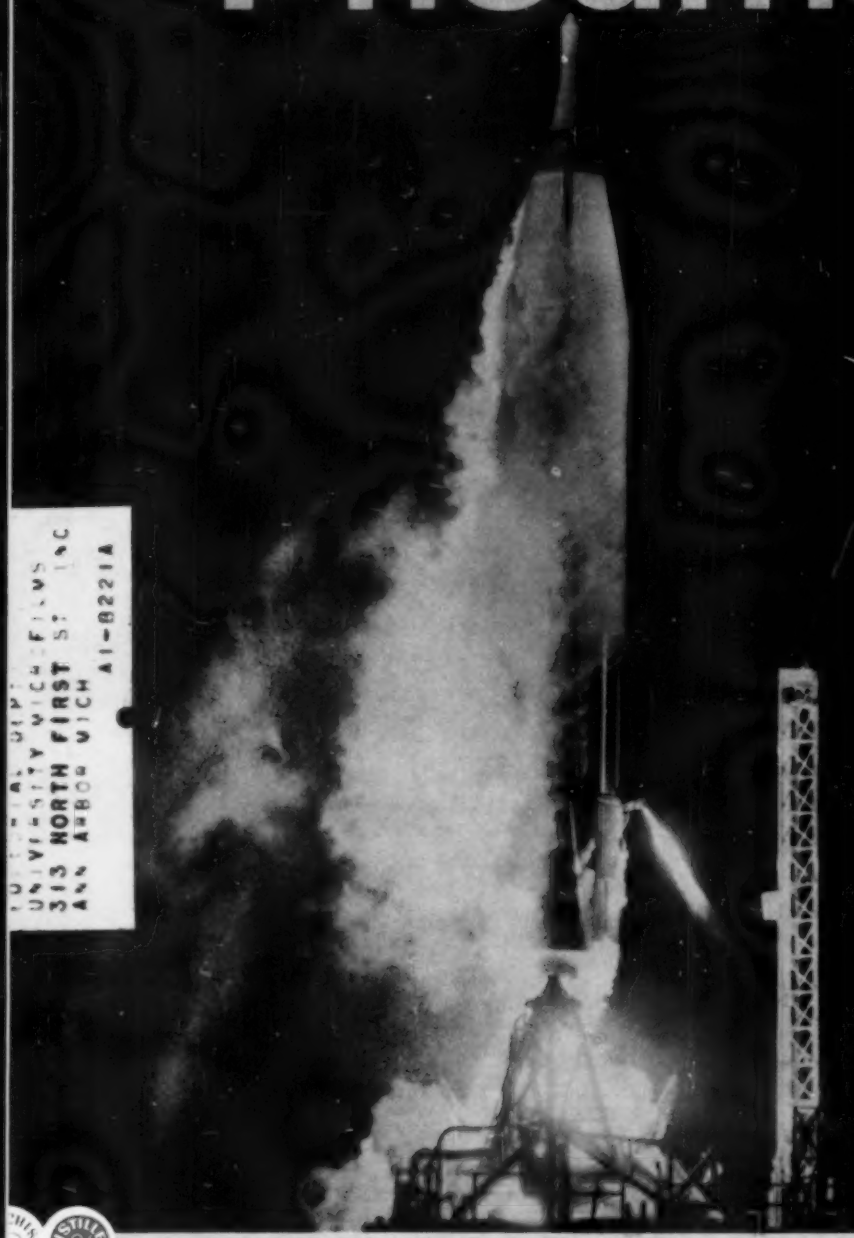
Hydraulics & Pneumatics

DECEMBER 1960



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Fluid Power In Space

SEE CONTENTS PAGE 3

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THE MAGAZINE OF FLUID POWER

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handles more air with minimum pressure drop

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RING LOCK COUPLING

Instant Automatic Flow or Shut-Off

Handles any job in your shop using 3/4" to 1/8" connections—from the air line to the air tool—eliminates any need for various size couplings in hook-up—makes it easy to keep stock of parts in balance—holds inventories to a minimum.

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WATER • VACUUM • STEAM • OXYGEN • ACETYLENE
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Here is an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings.

REPRESENTATIVES IN PRINCIPAL CITIES
. . . SEE YELLOW PAGES

SINCE 1915 — QUICK-CONNECTIVE FLUID LINE COUPLINGS

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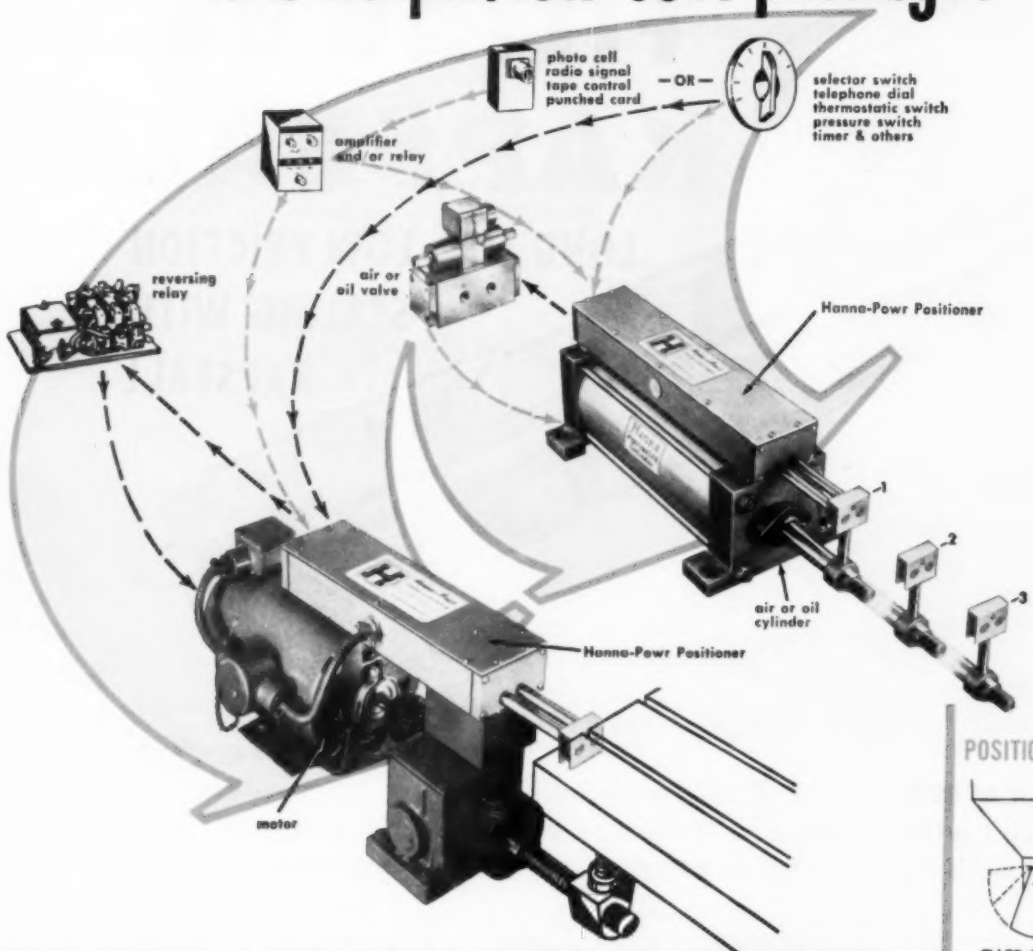

HANNA-POWR® POSITIONERS

THE NEW HANNA-POWR POSITIONER is a simplified, low-cost servo-mechanism used with air or hydraulic cylinders, electro-mechanical or other power drives to responsively achieve predetermined positions. The POSITIONER will also feed a signal to a read-out station to indicate the position point. Controls, such as selector switches, timers, thermostatic switches and others, feed signals to the POSITIONER for station selection—as many as 14 per foot of stroke. Infinite variations in positions are possible by simple movement of the adjustable limit switches. Stroke lengths may vary from a few inches to several feet to suit each application.

HANNA-POWR POSITIONERS save the time of designing special controls and cams, offer convenience of installation with one simple mounting for a group of controls, and cut maintenance costs by protecting all controls in a sturdy, dust-tight housing.

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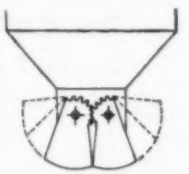
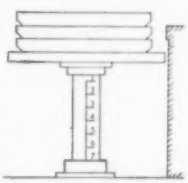
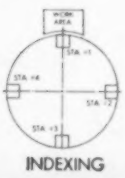
POSITIONED POWER



GATE POSITIONING



MULTIPLE POSITIONING OF LOADS



INDEXING

60 Years' Experience In Building The Finest Cylinders, Valves and Other Hydraulic and Pneumatic Equipment

Hanna Engineering Works

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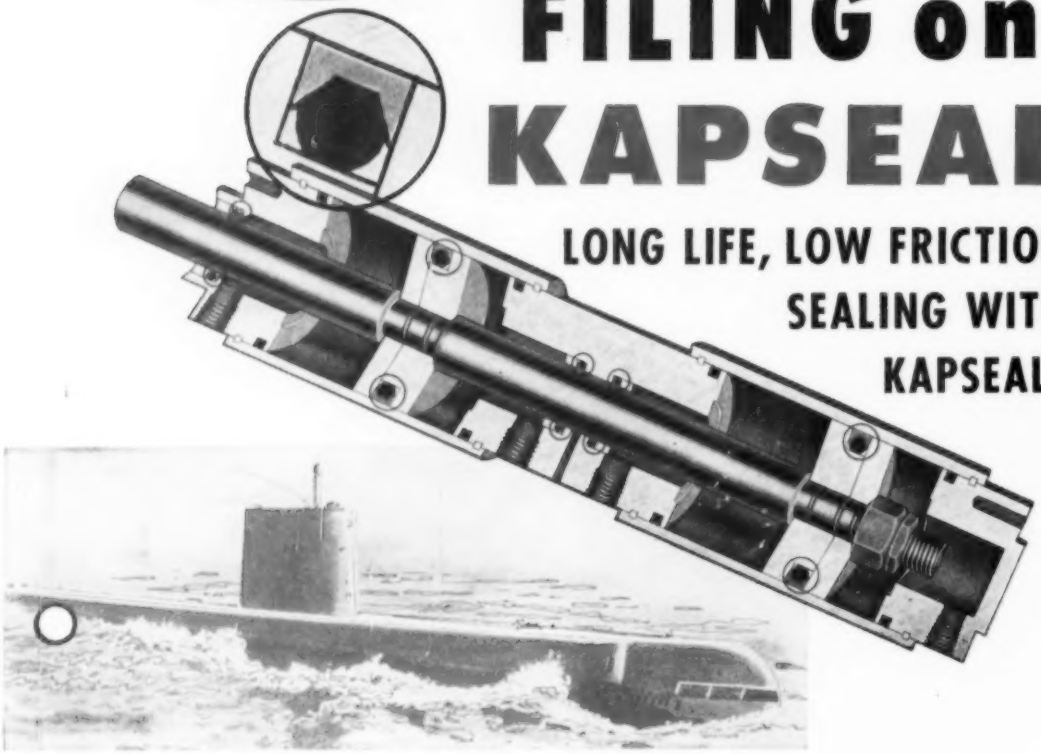
MINNESOTA MR RUBBER

FACTS for FILING on KAPSEAL®

LONG LIFE, LOW FRICTION SEALING WITH KAPSEAL!



The KAPSEAL® is a Teflon® "boot" which is used with a standard O-ring to provide a good seal with superior frictional and wear characteristics.

LONG LIFE The KAPSEAL has been tested on dynamic installations in both the laboratory and the field with outstanding results. Tests have run over 4,000,000 cycles before they were discontinued, while a hydraulic control valve has logged over 2,000,000 cycles. On a rod-seal installation it is performing satisfactorily at 1500 PSI.

LOW FRICTION The KAPSEAL is made out of Teflon because of the extremely low coefficient of friction this material has. It provides a sealing member with low breakout friction. Teflon is superior to rubber in this respect because its breakout and running friction are the same while rubber's breakout friction is about 50 times greater than its running friction. Thus the Kapseal-O-ring combination provide good sealing characteristics, and the ability to perform satisfactorily after prolonged periods of inactivity.

COMBINES WITH A STANDARD O-RING

The KAPSEAL comes in two styles, KIN and KEX. KIN is used when the ID of the seal is the sealing surface, while KEX is used when the OD is the sealing surface. The KAPSEAL combines with a standard O-ring and the combination can be installed in any gland that was designed for the O-ring only. The combination can also be used to replace stacks of V-rings giving a greatly simplified design. A "buttoned-up" design is possible because the long-life, low-friction characteristics of the KAPSEAL reduce seal replacement requirements to the extent that the mechanism can be sealed shut.

WHERE LIFE OR FRICTION IS A PROBLEM, THE KAPSEAL IS THE ANSWER

KAPSEAL is a trademark of Minnesota Rubber Co.
Teflon is a trademark of the DuPont Company

FOR MORE INFORMATION ON THE KAPSEAL . . .

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Hydraulics & Pneumatics

VOLUME 13/NUMBER 12

DECEMBER 1960

THE MAGAZINE OF FLUID POWER

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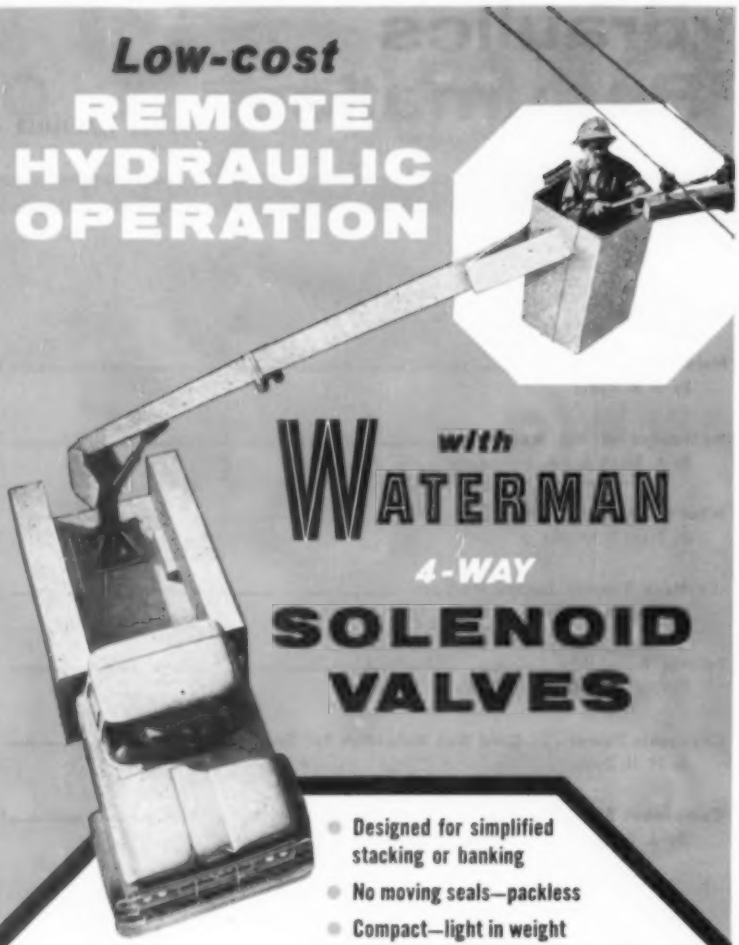
BPA

Low-cost REMOTE HYDRAULIC OPERATION



with WATERMAN 4-WAY SOLENOID VALVES

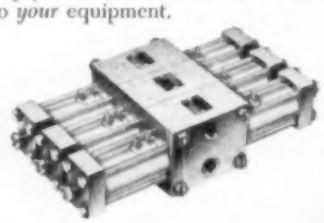
- Designed for simplified stacking or banking
- No moving seals—packless
- Compact—light in weight

"Up high at low cost," says Pitman Manufacturing Co., makers of this new "Pelican" aerial bucket. The utility crewman aloft is in complete control of rotation, extension, and elevation—through banked Waterman 4-Way Solenoid Valves operated from push-buttons on the bucket as well as from the cab.

Waterman design is an important factor in the simplified hydraulic circuitry that helps to keep down the cost of this new unit. Packless valve design—with no moving seals and all moving parts immersed in the hydraulic fluid—is a low-maintenance selling point. Let Waterman help you build convenience, versatility, and sales advantages into *your* equipment.

Designed for simplified stacking or banking

Convenience, low cost—and versatility, too—with Waterman 4-Way Solenoid Valves. Standard kits are available for stacking or banking up to six valves. Add on later if desired, to build in other hydraulic functions. A.C. or D.C. Rated at 3000 p.s.i. ½" N.P.T.F.



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USEFUL LITERATURE

NEW CATALOG FOR REPLACEMENT LINE OF ANCHOR HYDRAULIC HOSE ASSEMBLIES, COUPLINGS, HOSE AND FITTINGS

For better, faster service for users of fluid power equipment requiring replacement hydraulic components, the Anchor Coupling Co. Inc. consolidated catalog—No. D-2 describes the complete *replacement* line of Anchor Pressed-On Hydraulic Hose Assemblies, together with Anchor Reusable Couplings, Hose and Fittings. These Anchor products are carried in stock for immediate pick-up or delivery from Anchor distributors.

Prepared for quick reference, selection and ordering, catalog No. D-2 shows the comprehensive Anchor line of Pressed-On Hose Assemblies.

Anchor Super-Spiral Wire Reinforced High Pressure Hydraulic Hose Assemblies with Pressed-On Couplings, offering the highest burst and working pressures available in hydraulic hose assemblies, are completely described, with detailed specifications.

In addition, the new Catalog shows Anchor high pressure Pressed-On Hydraulic Hose Assemblies for extra strength Two Wire Braid, standard Three Wire Braid, and extra strength Three Wire Braid Hose.

Featured are Anchor's high pressure Two Wire Braid hose (SAE 100R2) assemblies with Pressed-On, Clamp-Type or Coverstrip Reusable Couplings, together with Anchor's medium and low pressure One Wire Braid (SAE 100R1) Assemblies with Pressed-On Couplings or Reusable Couplings. For non-flammable hydraulic fluids (Phosphate Esters), Anchor's High Pressure Two Wire Braid Hose Assemblies with Pressed-On Couplings are recommended.

Medium and low pressure One Wire Braid Cotton Cover Hose (Style QW-SAE 100R5) and One Wire Braid Rubber Cover Hose (Style QWR) Assemblies with Duloc Reusable Couplings are illustrated.

Described in detail are Anchor Max-Flo Hi-Burst Two Ravon Braid Hose (Style HR-SAE 100R3) and standard Style R Two Ravon Braid Hose Assemblies with Pressed-On, Clamp-Type and Reusable Couplings.

For suction, low pressure or gravity flow hydraulic lines, Anchor Max-Flo Spiral Wire Reinforced Suction Hose (Style SW-SAE 100R4) Assemblies with Pressed-On or Clamp-Type Couplings are shown.

Also illustrated are Anchor Style PR Rubber Cover 1-Cotton Braid Hose and Style PQ Cotton Cover 1-Cotton Braid Hose Assemblies with Anchor Hold-Fast Couplings for low pressure automotive, marine and industrial applications.

The Couplings section of Catalog No. D-2 gives detailed specifications for Anchor high, medium and low pressure Clamp-Type Reusable Couplings and Coverstrip Reusable Couplings for Two Wire Braid hose (SAE 100R2) and One Wire Braid Hose (SAE 100R1); DULOC Reusable Couplings for Style OW (SAE 100R5) and Style QWR hose; Reusable Couplings for Hi-Burst and standard Two Ravon Braid, Style HR (SAE 100R3) and Style R hose.

Described in detail are Anchor 4-Bolt Split-Flange "O" Ring Head Clamp-Type Couplings for use with the above mentioned hose. Also included are Anchor Split Flanges and components. Anchor's Hold-Fast Reusable Couplings, in a wide variety of styles and sizes, are described.

The Anchor line of Adapter Unions, Adapters, Pipe Fittings and SAE Boss Fittings for hydraulic and industrial uses, with the largest variety of three combinations—standard, JIC, SAE, etc.—is included in the new catalog.

Copies of Anchor No. D-2 Catalog are available at Anchor distributors, or can be obtained by writing direct to Anchor Coupling Co. Inc., Box 111, Dept. AAA, Libertyville, Illinois.

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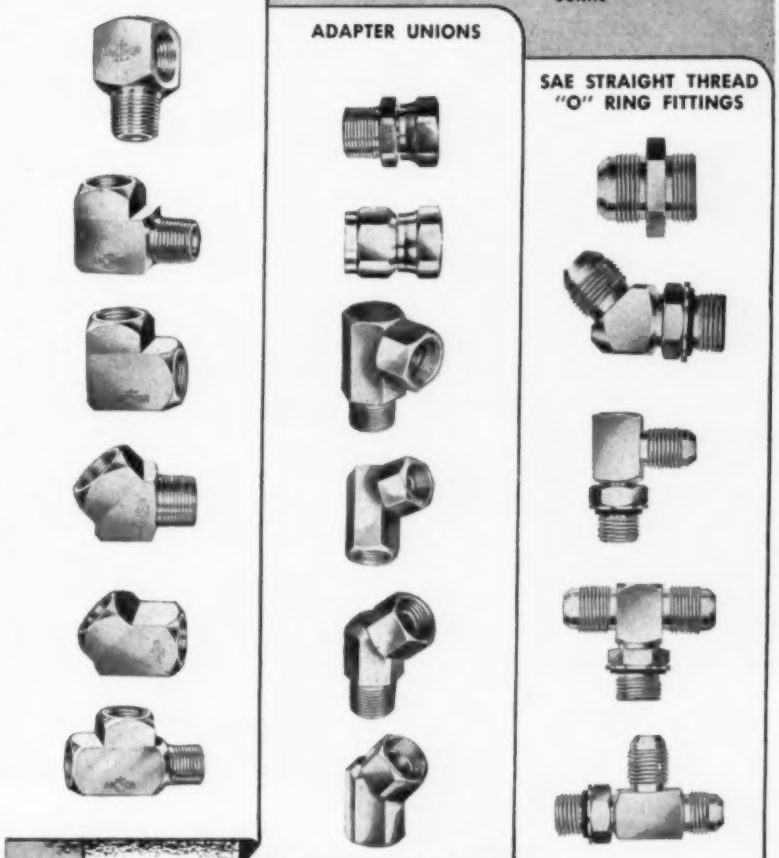
Simplify
Your Hydraulic Connections with ANCHOR®

- Prevents Hose Strains Caused by Twisting during Assembly
- Safer, More Positive, Leak-Proof Connections
- Easier Assembly in Confined Spaces
- Eliminates One or More Pipe Thread Joints

PIPE FITTINGS

ADAPTER UNIONS

SAE STRAIGHT THREAD "O" RING FITTINGS



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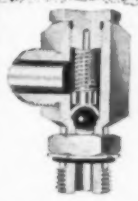
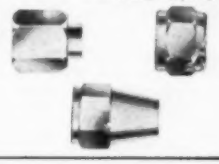


TUBE NUTS



Andy Anchor says:

For complete specifications on these precision-made, space saving, trouble saving, hydraulic fittings, write today for Anchor's New Catalog No. 206

ANCHOR COUPLING CO. INC.

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interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads [illegible] Mounting [illegible] Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 "V" Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

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Circle 97 →

...Fluid Power news

REPORT NO. 12,108 OILGEAR HOLD-DOWN AND LIFT SYSTEMS

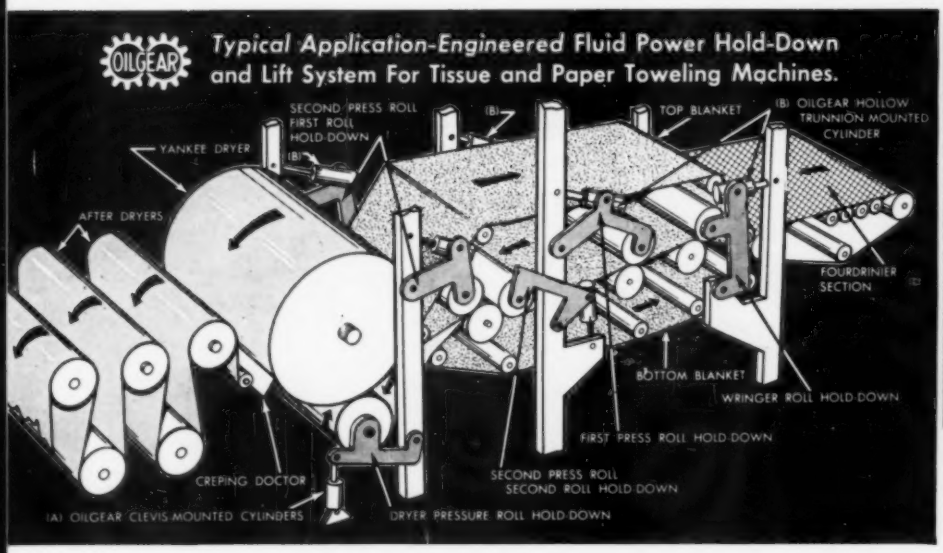
From Oilgear *Application-Engineering* Files

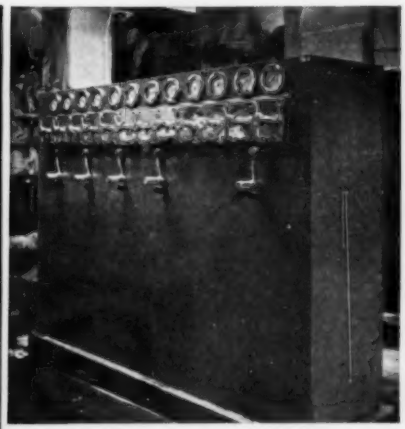
HOW OILGEAR HOLD-DOWN AND LIFT SYSTEMS INCREASE ROLL LIFE—IMPROVE PRODUCT QUALITY

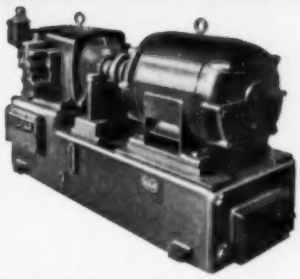
USER: *Scott Paper Company, Chester, Pa.; Everett, Wash.; Mobile, Ala.; Fort Edward, N.Y.*

PROBLEM: To supply hold-down and lift systems for rolls on paper machines, paper coating machines, super calendars, laminating and similar processing machines — that can be accurately controlled from a simple remote control panel.

USER REQUIREMENTS: 1. Provide constant, uniform, preset roll pressures. 2. Smooth lowering and/or forcing of pressure rolls downward to avoid damage, such as fracturing or flatting. 3. Fast, easy, positive selection of such functions as "Lower," "Hold Down," "Release," "Lift," "Hold Up," "Off." 4. Accurately, infinitely vary the pressure on either end of each roll independently over a wide range, at any time, to balance the opposing forces created for most efficient machine operation and product quality. 5. A direct-reading, constant, visual indication of the pressure and force exerted on either end of each roll. In addition, the systems must be simple . . . clean . . . easy to install and maintain . . . facilitate replacement of worn rolls . . . trouble-free, dependable, heavy-duty, for continuous, 'round-the-clock operation.







Top Photo: One of the Oilgear Hold-Down and Lift System Control Panels as installed with each of Scott Paper Company's two, new tissue machines in their Southern Division Mill, Mobile, Ala.—symbolized in the schematic drawing, left. Daily production from these machines averages 200 tons of Scott's bathroom tissues, toweling and wipers for household and industrial use. **Right:** A typical Oilgear Heavy-Duty **"Power-Pak"**—Variable Displacement Pump, electric motor drive, and reservoir base — used with Hold-Down and Lift Systems.

SOLUTION: *Oilgear Application-Engineered Hold-Down* and Lift Systems consisting of Oilgear Heavy-Duty, Constant or Variable Displacement Pumps that supply *Fluid Power* to Oilgear "Custom-Quality" Cylinders through separate Oilgear Valves on a remote control panel — provide smooth, positive motion and steady, preset holding pressures. Cylinders can be mounted directly, or through mechanical linkage, to pressure roll bearing ends. Simplicity of pump drive and installation keep machine cost at a minimum. Remote Control Panel provides fast, positive selection of all functions — operator can "Lift," "Hold Up," "Release," "Lower," "Hold Down" — at any time; accurately, infinitely vary pressure on either end of each roll independently, and have constant, direct-reading, visual indication of pressure and force being exerted at bearing ends of *each roll.*

ONE USER STATES—*"The control panel indication is so accurate that a worn, 'off-balance' or out-of-round roll can be readily detected."*

Another User Reports — *"Oilgear is far superior to other systems . . . direct gage readings have enabled us to experiment with varying degrees of pressure on the rolls, so that we can operate with less pressure than we hitherto thought feasible. This has resulted in improved product quality and longer roll life."*

Oilgear is no "stranger" in the paper industry . . . other Oilgear Linear Drives are in operation on pulp log splitters and pulp baling presses. Similarly, the highly efficient, long-life, Oilgear Heavy-Duty Variable Speed Rotary Drives are compiling enviable records on special purpose paper machine sections . . . on complete paper machines . . . on multi-color printing press drives . . . or unwinder and winder drives . . . on laminating and coating machine drives. It's well worth your while to consider Oilgear — *"for the lowest cost per year!"*

For practical solutions to YOUR linear or rotary motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Fluid Power Systems

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MARVEL
IN-LINE FILTER
CAPACITIES: Up to 60 G.P.M.
PIPE SIZES: ¾"—1"—1¼"—and 1½" (at both inlet and outlet).
BY-PASS VALVE: Available with or without.
Bonded LINE TYPE
CAPACITIES: 10—20—30—50 and 75 G.P.M.
PIPE SIZES: 1"—1¼"—1½"—2" and 2½".
BY-PASS VALVE: Available with or without.
OPERATING PRESSURE: Up to 250 p.s.i.
OPERATING TEMPERATURES up to 300° F.

QUALITY–DEPENDABILITY–EFFICIENCY

A simple formula–but is foremost in the design and construction of all Marvel Filters

–Over 900 O.E.M.s can't be wrong–

Designers and manufacturers of hydraulic equipment requested suction filters incorporating special features.

For example—a by-pass valve to assure instant flow of hydraulic oils on construction and earth moving equipment during cold weather operations. Three of the filters illustrated are available with this important feature.

The Tandem Sump Type Filter supplies the demand for a single unit to handle greater capacity where space limitations present a problem for multiple unit installations.

We are pleased to advise that all units are now stock items and are being supplied to many of over 900 Original Equipment Manufacturers who are installing them as standard equipment.

For Dependable Protection on all Hydraulic and other liquid circulating systems – Investigate MARVEL Synclinal Filters

For further information—write, wire or phone

does it again!

Designers asked for these filters—

MARVEL is delivering them now!

Tandem SUMP TYPE
CAPACITIES: 10—16—20—40—60—100—150 and 200 G.P.M.
PIPE SIZES: ¾"—1"—1¼"—1½"—2"—2½" and 3".
CONNECTIONS: Coupling—Male Nipple.
BY-PASS VALVE: Not available.
Bonded SUMP TYPE
CAPACITIES: 10—20—30—50 and 75 G.P.M.
PIPE SIZES: 1"—1¼"—1½"—2"—and 2½".
CONNECTIONS: Coupling—"O" Ring—Male Nipple.
BY-PASS VALVE: Available with or without.

MARVEL ENGINEERING COMPANY

7227 NORTH HAMLIN AVENUE, CHICAGO 45, ILL. • PHONE: JUniper 8-6023

Please send me information on Marvel Filters as indicated.

- ☐ Sump Type
- ☐ Line Type
- ☐ In-Line
- ☐ Tandem
- ☐ For Hydraulic Oil
- ☐ Fire Resistant Fluids
- ☐ For Coolants or Lubricants
- ☐ For Water

AH-12

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City _____ *State* _____

FLUID POWER LINES

about hydraulics & pneumatics

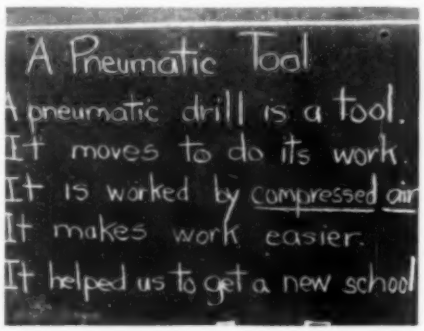
INTO THE WILD BLUE YONDER . . . With each year's Missile Issue, we are caught by the fast paced excitement of aerospace research. More than ever before, this issue represents advanced thinking—not only about projects now in the works—but also about those to come. What jobs can fluid power do most effectively on space craft? How can ground support equipment meet more complex handling and check-out requirements? What problems will have to be solved so fluid power can meet the reliability requirements of maintenance-free operation on long interplanetary flights? How about radiation? . . . temperature extremes? . . . environmental effects like absence of atmospheric pressure and oxygen? More specifically, how will conditions on the moon affect hydraulic and pneumatic equipment? Temperature there ranges from —240 F at night to +240 F during the day. With no atmosphere, ultraviolet and X-ray radiation from the sun will be very strong, leakage will be even more of a problem.

These are some of the areas that concern engineers responsible for developing the design concepts and technology for exploring outer space. Some of their thinking is expressed in the editorial pages of this issue. Some of the results are shown there too, in working hardware that itself was in the dreaming stage only a short time ago.

BLOWING HOT AND COLD . . . *Hot gas* has a magic sound in aerospace technology these days. Hot gas servo systems are developing fast, some are operational. But how about *cold gas?* In liquid-fueled rockets, it's there for the taking by boiling off some of the propellant. Howard Davis has worked out a proposed system in his article *Cryogenic Power . . . Cold Gas Actuation for Space Vehicles.* He shows how to size components for engine thrust-vector control.

HOW GOOD IS BEST? . . . Components which *just* do the job don't stay around long in a missile program. Designers are constantly pushing to do better, and the word *optimization* has been invented to describe this effort. Results of an optimization program are told in the Lockheed story, *Component Sizing for Missile Thrust Vector Control.* The thrust-vector control system packages pump-motor, accumulator, valving, reservoir, and actuator.

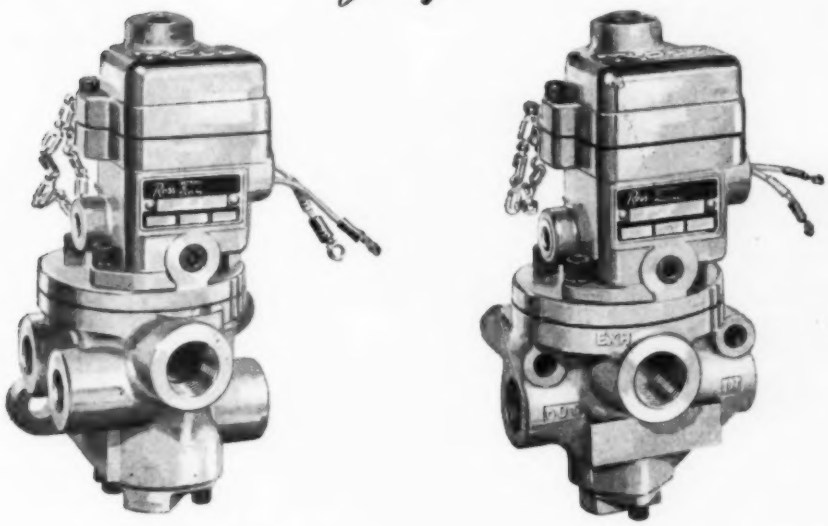
SPACE AGE EDUCATION . . . It starts early in Cockeysville, Md. where schoolteacher Ruth Stroh gave this lesson in compressed air as it was being used to build a new school building. A wonderful example of *distilled* writing.


A Pneumatic Tool
A pneumatic drill is a tool.
It moves to do its work.
It is worked by compressed air
It makes work easier.
It helped us to get a new school

PILOTS ON THE GROUND . . . When they designed the Transrector described in *Pilot Control for Pressure Sequencing,* Hufford engineers decided the best way to sequence a hydraulic crane for handling rocket engines is by pilot control. Here's a real exercise in circuit operation, using a telescoping cylinder to raise the boom initially, then passing the job on to a double-acting cylinder.

Ross

Proudly presents



THE NEW "HEADLINE" SERIES

A complete new series of inline valves, sizes one-quarter inch through one and one-half inch, straightway, 3-way and 4-way. These valves, size for size, will operate faster, longer, and provide greater capacity than any other valves we have been able to find.

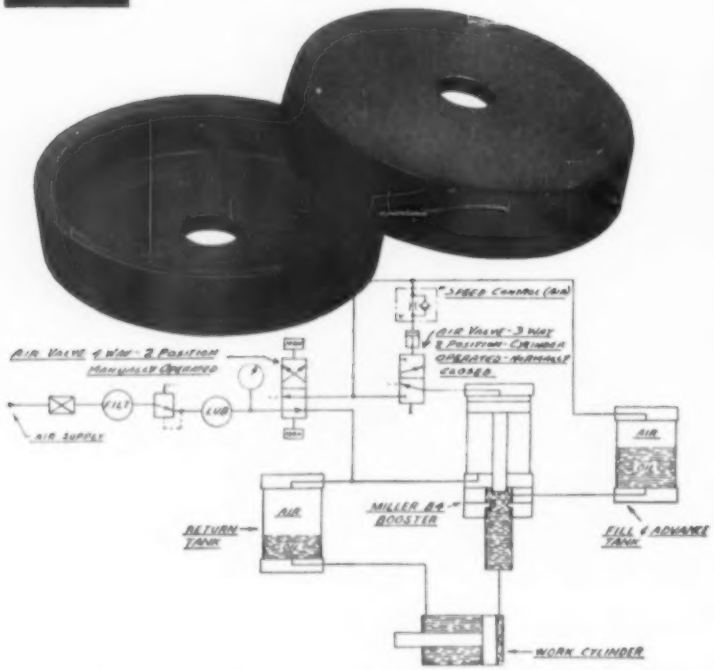
When the price, quality and performance and Ross reputation are taken together in evaluating this series, it represents probably the best valve value available today. Before you specify any valve after today, you owe it to yourself to look into the "headline" series. Write for full information.

Ross OPERATING VALVE COMPANY

105 EAST GOLDEN GATE AVE. • DETROIT 3, MICHIGAN

MECHANICAL LEATHERS

in Design Engineering



Garlock leather packings are formed with minimum radius at heel to assure longer service life against cold and hot water, oils, air or fire-safe phosphate ester fluids.

Under many service conditions leather packings do a much better job than other materials in preventing leakage of hydraulic and pneumatic media.

Low Coefficient of Friction—Leather materials retain lubricants, create less than half the friction of other common packing materials. Lower friction means smooth easy movement and long service life.

High Tensile Strength—Leather packings will withstand the highest operating pressures and shock loads because of their interwoven natural fiber structure. Average strength measures 3000 PSI.

Lower Cost—Based on longer service life and fewer overhaul or repacking jobs, leather packings save you in reduced downtime and maintenance labor.

Will Not Score or Abrade—In rough unfinished cylinders, leather will polish metal surfaces which they contact, will not abrade under conditions which would destroy other packing materials.

Long Storage Life—Leather will not deteriorate due to oxidation or sunlight. They can be kept in stock indefinitely without loss of essential qualities.

In any of three leathers—BITAN*, Chrome, or Oak—Garlock can furnish all shapes, sizes, and designs of leather packings for hydraulic use. They're made in a modern packing plant which maintains highest standards of quality. Molded Cups, "U" Packings, "V" Packings, Washers, Gaskets, Discs, Flange or Hat Packings are some of the more commonly specified types. Sizes range from 1/8" O.D. leather washers for needle valves to 99" O.D. "U" Packings . . . rubber, plastic or wax impregnations.

GARLOCK

Contact your Garlock representative at the nearest of our 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for Catalog AD-121, Garlock Inc., Palmyra, N. Y.

Canadian Division: Garlock of Canada Ltd.

Order from the Garlock 2,000 . . . two thousand different types of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

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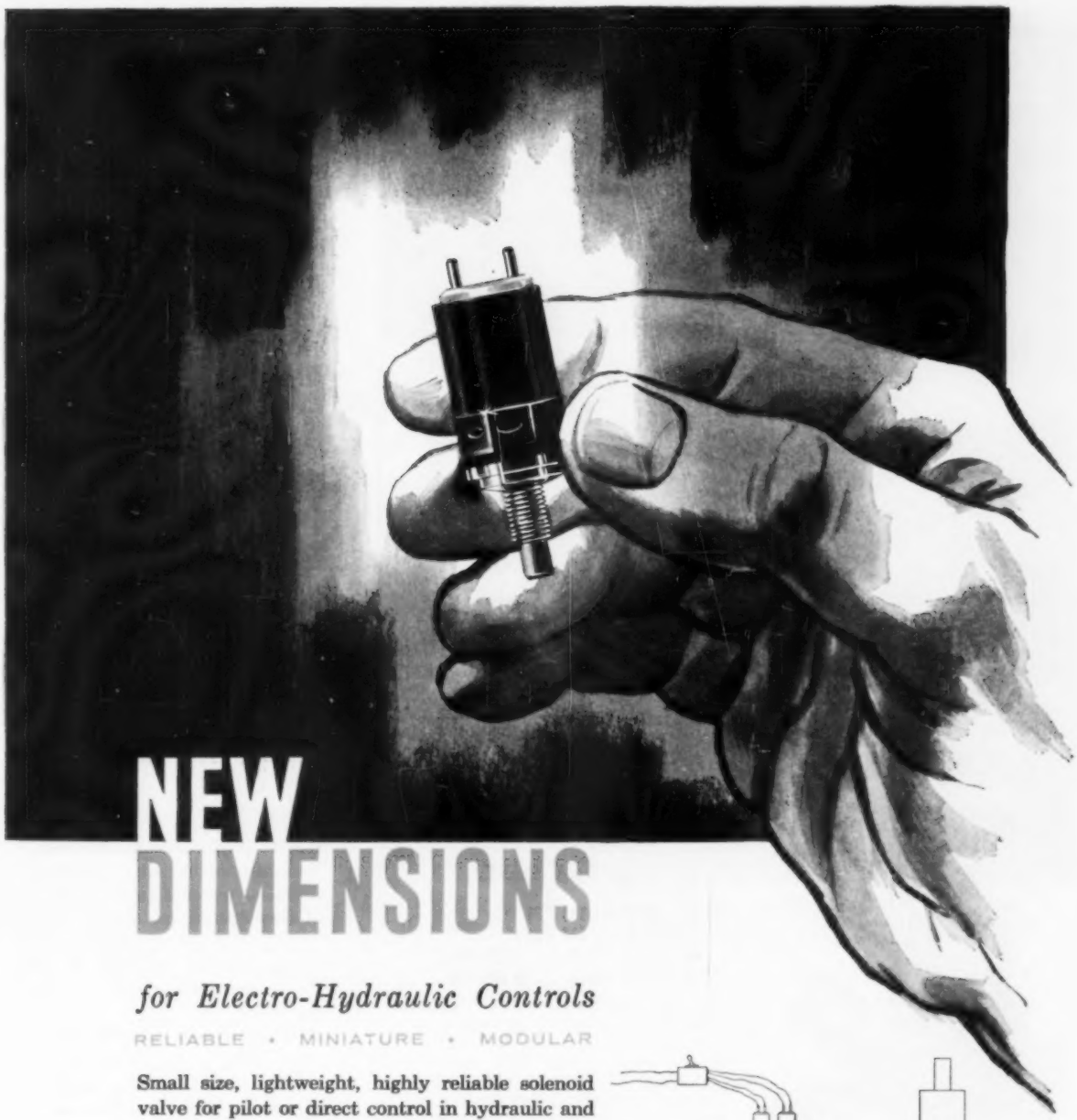


NEW DIMENSIONS

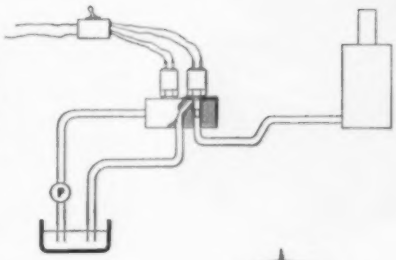
for Electro-Hydraulic Controls

RELIABLE • MINIATURE • MODULAR

Small size, lightweight, highly reliable solenoid valve for pilot or direct control in hydraulic and pneumatic systems. Features integral construction of unique pilot operated valving with solenoid actuation. Available with pin, pigtail or clip type electrical connectors.

- **Pressure—3000 PSIG (higher pressure settings available)**
- **Flow (MIL-5606)—.80 G.P.M. @ 100 P.S.I. drop**
- **Voltage—D.C., various options available**
- **Weight—1.75 oz.**
- **Opening and Closing—60 complete cycles per second**
- **Sealing—Drop tight**

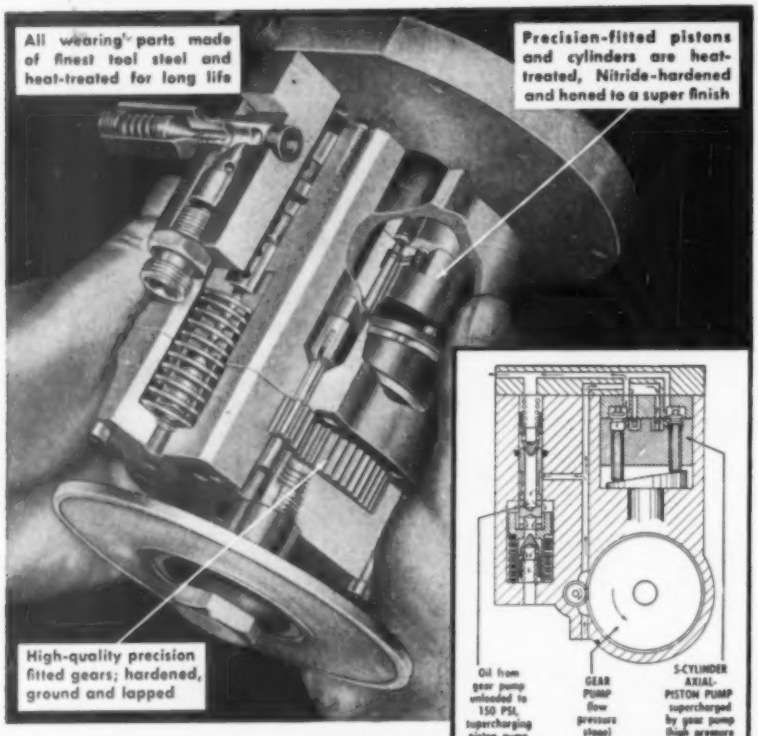
Smaller and larger size valves available.



SPARD

Division of The Electric Autolite Company

Direct inquiries to SPARD Division, The Electric Autolite Company, Toledo 1, Ohio


All wearing parts made of finest tool steel and heat-treated for long life
Precision-fitted pistons and cylinders are heat-treated, Nitride-hardened and honed to a super finish
High-quality precision fitted gears; hardened, ground and lapped
Oil from gear pump unloaded to 150 PSI, supercharging piston pump
GEAR PUMP (low pressure stage)
5-CYLINDER AXIAL-PISTON PUMP supercharged by gear pump (high pressure stage)

For operating pressures up to 10,000 PSI

New, unique 2-stage hi-pressure hydraulic pumping unit—dual-volume, dual-pressure

- **DELIVERS HIGH-VOLUME AT LOW PRESSURE**
- **2.6 GPM @ 100 PSI**
  1.75 GPM @ 500 PSI
  80 CU. IN./MIN. @ 1,000 PSI
  50 CU. IN./MIN. @ 10,000 PSI

The new and modern OTC "Vanguard" hi-lo hydraulic power package is a precision-built, high-quality unit meticulously crafted for dependable performance and long life. To best utilize the "Vanguard's" exceptional performance, a wide range of accessories are available: your choice of several motors, gasoline engine, 2 and 4-way lever-control valves, 2-way solenoid valve, pressure switch, pressure regulating valve, manifold, reservoirs, gauges, etc.

For detailed information on this advanced, new unit, write:

PRECISION HYDRAULICS DIVISION
OWATONNA TOOL CO.
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RESEARCH · ENGINEERING · DEVELOPMENT
OTC

DESIGNERS AND MANUFACTURERS OF QUALITY HIGH PRESSURE HYDRAULIC COMPONENTS

Circle **100** on Reader-Service Card

LETTERS to the editor

Address your letters to: Editor, HYDRAULICS & PNEUMATICS MAGAZINE, 812 Huron Rd., Cleveland 15, Ohio.

In-line relief valve

TO THE EDITOR:

In the October, 1960 issue of your magazine, page 132, you have a short article on an in-line relief valve. I would appreciate any further information you can give me on the valve.

GRANT V. HOYT
Service Manager
The Kartridg Pak Co.
Mount Prospect, Ill.

We suggest you contact Mr. Walter Mason or Mr. Stephen J. Biello at Avco, Inc. in Rhode Island. This was covered in their Patent No. 2,884,952.

Improved die loading circuit

TO THE EDITOR:

The other day a couple of our special projects engineers and I were discussing some hydraulic problems we were having, and one of them handed me the November 1959 issue of HYDRAULICS & PNEUMATICS opened to page 93 with the remark, "I'll bet they are having fun."

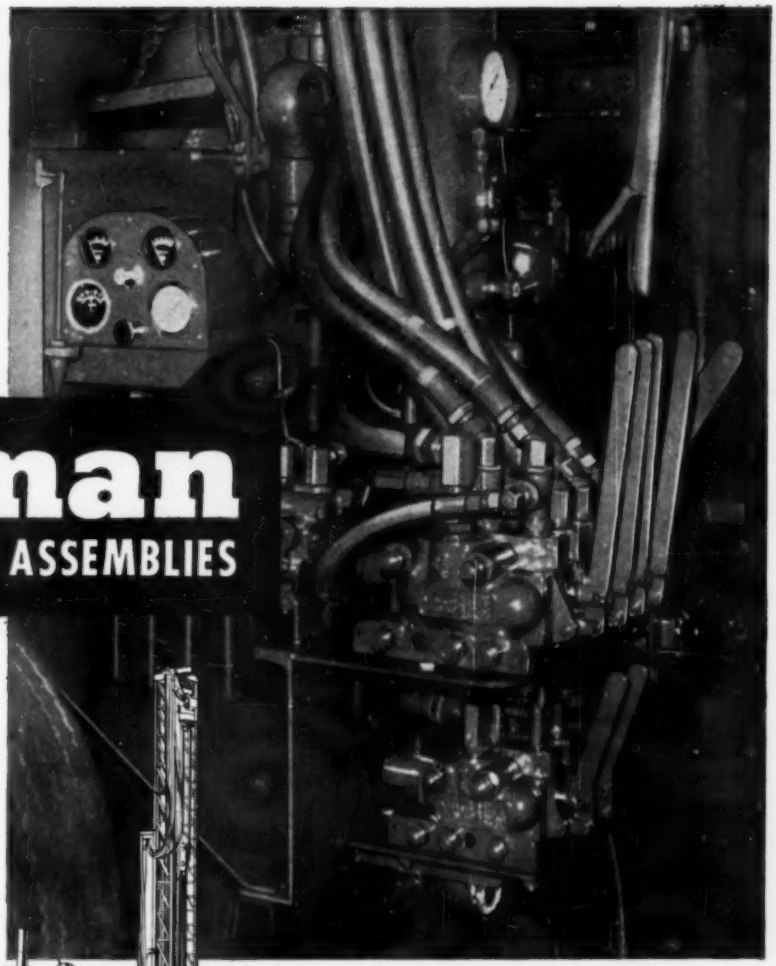
We have been using this method since 1946 or '47 so we all took a moment to chuckle over the schematic. (This describes a special air-oil intensifier that replaces die springs in presses. See circuit A). Of course we were thinking of it in relation to our operations. It is very good at low speed but when you get over about 20 strokes per minute with small cylinders, the oil heats up to excessive temperatures. (We consider anything over 120 F excessive.) Then you have two choices: (1) cool the oil in some manner, (2) change the hydraulic circuit. We run from 50-90 strokes per minute so we chose method two.

We separate the pressure relief valve and the check valve and

Continued on page 16

THE KEY TO A DEPENDABLE SYSTEM!

Eastman
HYDRAULIC HOSE ASSEMBLIES



EASTMAN designs complete hydraulic operation for SCHRAMM Rotadrill

Valves mounted in three convenient banks for each outrigger, forward and reverse rotation of motor, slow down speed, rapid down speed and for breakout cylinder.

The cooperation of EASTMAN Engineering was enlisted in making the operation of this truck-mounted Schramm Rotadrill *completely hydraulic.*

Hydraulic power is delivered through EASTMAN Hydraulic Hose Assemblies to:

1. Three-Speed Reversible Rotation Head: Standard speeds—44, 65 and 120 r.p.m. with 26,500 inch pounds torque. 2. Cylinders controlling down feed, rapid feed and slow feed. 3. Controls for raising and lowering of mast. 4. Breakout Cylinder. 5. Hydraulic Winch and Hook. 6. Three Outriggers.

Dependable field service is assured through EASTMAN Two-Wire Braid High Pressure Hose with Permanently Attached Couplings providing a bond stronger than the hose itself.

Efficient power delivery through the extensive, multiple circuits of this rock-drilling rig is obtained through EASTMAN designed permanently attached hose assemblies which insure longer life and lower cost.

ENGINEERED FOR ENGINEERS BY ENGINEERS

Let EASTMAN Engineering assist you in planning the initial layout of your hydraulic system—for most efficient power delivery and lowest cost.

PERMANENTLY ATTACHED COUPLINGS
for 1, 2, and 3 wire braid rubber cover hose

REUSABLE COUPLINGS
for fabric cover hose

REUSABLE COUPLINGS
for rubber cover hose

CLAMP COUPLINGS
for 1, 2, and 3 wire braid rubber cover hose

Write today for Bulletin 100 and 200 on EASTMAN High, Medium and Low Pressure Hydraulic Hose Assemblies.

Eastman MANUFACTURING COMPANY
Dept. AH-12, MANITOWOC, WISCONSIN

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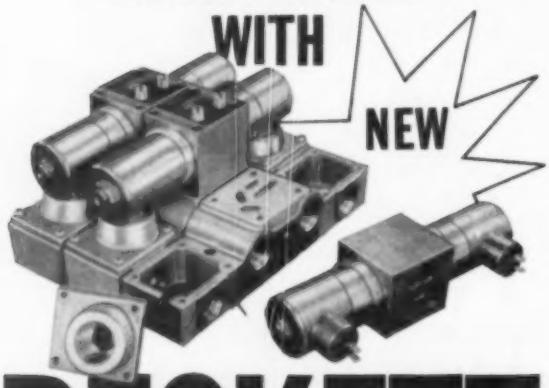
SAVE ON LABOR COSTS WITH NEW



BECKETT

Hi-Cyclic STACKING MANIFOLD AIR VALVES

- Change a valve in about 2 minutes or less without disturbing piping or wiring. Remove 4 bolts and lift off valve.
- Plug-in solenoid connections—no re-wiring needed to replace a valve.
- Large manifold capacity—add valves at any time, using same air supply.
- Manifold accepts 2 or 3-position, 1/4", 3/8" and modified 1/2" sizes. 1/4" valve mounts on 2 1/8" centers; 3/8" and modified 1/2" valves mount on 2 5/8" centers.
- Wide open bus duct-type wiring area makes for easy installation of electrics.
- Built-in speed controls—with instruction plate that identifies direction for speed regulation.
- These new Beckett Hi-Cyclic Air Valves provide fast reaction for accurate control. There are no working packings—seal is by precision metal-to-metal fit. Only the stainless steel spool and brass valve body in contact with media. Seven spool types are available to meet all requirements. New Hi-Cyclic Stacking Manifold Valves will save you money on direct labor costs for installation and replacement. Write today for full details.

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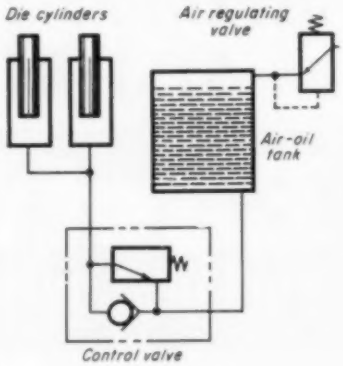
BECKETT-HARCUM CO.

981 W. LOCUST STREET, WILMINGTON, OHIO

Circle **22** on Reader-Service Card

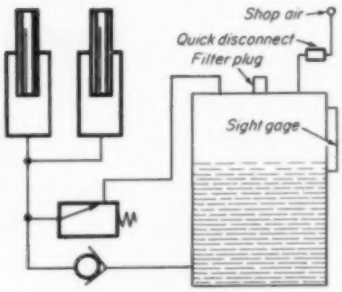
LETTERS

dump the pressure relief valve into the top of the reservoir; supplying oil to the cylinders through the



Circuit A

check valve from the bottom of the reservoir. In this way we can vary the reservoir size to suit the job and need no further cooling. We also keep our valves as close



Circuit B

to the die as possible and use steel tubing because our pressures go as high as 7000 to 10,000 psi. See circuit *B*.

You can use a sequence valve in place of a pressure relief valve with equal success at pressures under 2000 psi.

This episode confirms what we told you some time ago, "around here HYDRAULICS & PNEUMATICS gets worn out, not discarded".

MARLIN BENSINGER
Oldberg Manufacturing Co.
Grand Haven, Mich.

We certainly appreciate your taking time to explain your modifications of the design which we presented in the November issue.

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

Flexible, high-accuracy simulation with DENISON hydraulic pump power for...

CHECKOUT

HYDRAULIC CHECKOUT UNIT, *designed and built by Sun Electric Corp., Chicago (shown with access panels removed) is powered by a Denison 800 Series Variable Volume Piston Pump—shown below with handwheel control.*

With Denison Variable Volume Axial Piston Pumps powering your hydraulic checkout equipment, you assure *high-accuracy simulation.*

These pumps (with volumes to 116.7 gpm and pressures to 5000 psi) allow a wide range of pressures and flows to be selected with fine-line variations. You get the multi-purpose flexibility needed for today's checkout equipment.

Denison Variable Volume Piston Pumps—and *all* Denison hydraulic components—are precision manufactured for long, maintenance-free life. Result—you can spend more time checking-out... less time checking-up.

Ask your Denison Hydraulics Specialist—located in all principal cities—to show you how Denison hydraulic equipment—pumps, motors, valves, controls—can help you improve the performance of your GSE systems.

Write for your copy of new Bulletin 204, "Advanced Hydraulic Components For Ground Support Equipment".

DENISON ENGINEERING DIVISION
American Brake Shoe Company
1166 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

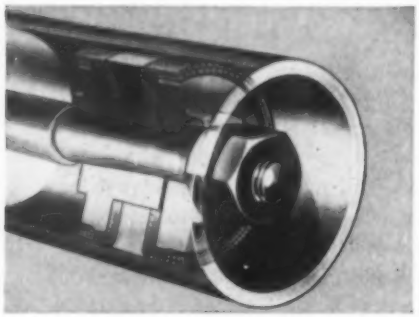
DENISON
HYDRAULIC POWER

PUMCUPS

outlast ordinary packings

3 TO 1

- *in hydraulic and pneumatic mechanisms*
- *in reciprocating pumps*



With Darcova Pumcups...regardless of wear, pressure keeps Pumcups hugging cylinder wall.

Operating costs go down and efficiency goes up when Darcova Pumcups go in! Here's why:

- **Pumcups outlast other packings at least 3 to 1, based on actual reports from users**
- **Fluid slippage is virtually eliminated, because Pumcups operate at full efficiency throughout their entire life**
- **Maintenance costs are reduced, because you have fewer replacements, less downtime.**

Available in three textures—hard, medium and soft. Also in regular or 100% nylon composition. Size ranges from ¾" to 20". For *all* the facts on Darcova Pumcups, write for Bulletin 5903.

DARLING VALVE & MANUFACTURING CO.
Williamsport 15, Pa.

DARCOVA
THE ORIGINAL COMPOSITION CUP
TRADE MARK
PUMCUPS

Circle **41** on Reader-Service Card

FLUID POWER FORUM

Each month HYDRAULICS & PNEUMATICS surveys readers for their experiences and opinions in fluid power design.

• Are you using fire-resistant hydraulic fluid? What type do you prefer? What difficulties have you had with it, and what improvements would you like to see?

We are using a water glycol, fire-resistant hydraulic fluid in a hydraulic power unit being built for a defense agency. The pumps are axial piston, 60 gpm and 3000 psi. We have found that extreme care must be taken so that fluid will not evaporate. Also we must be certain to circulate fluid before pumping as the surface cakes when left standing. It does perform well.

JULES KENDALL
General Manager
Kenett Corporation
Brookline, Mass.

We are using fire-resistant hydraulic fluids and I have no preference as to type. Generally, hydraulic equipment using fire resistant fluids cost more than equipment using petroleum oil. In most cases the special seals are not compatible with seals for regular oil. This presents a spare parts problem.

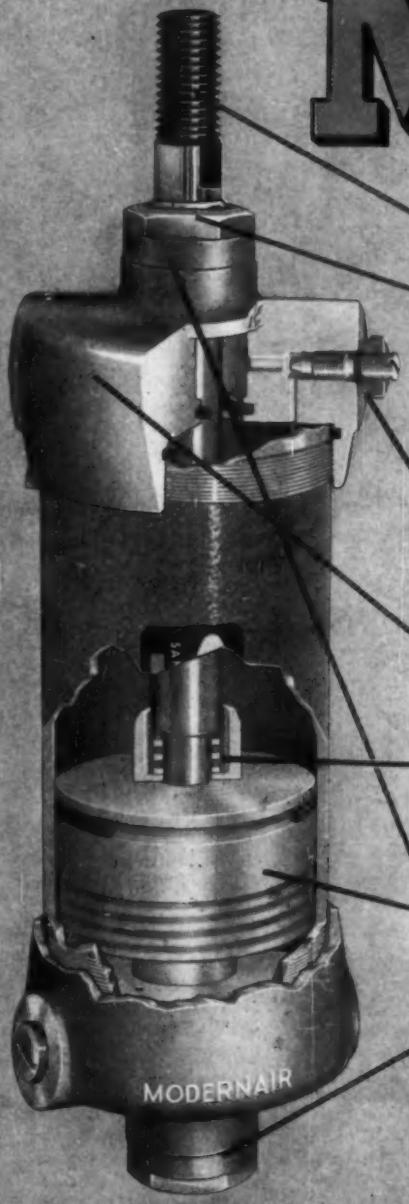
The life of most hydraulic equipment is shorter when using fire-resistant fluids. This is particularly true of non-hydraulic-balanced units. Some water-based fluids lose their viscosity and lubricity if the specific gravity is allowed to change from that recommended.

Generally, fire-resistant fluids have, I believe, been over-sold to the general user, so that the "danger" of using hydraulic equipment with petroleum based fluid has sometimes worked to the detriment of the hydraulics industry.

Continued on page 20

another **NEW PRODUCT** *from* Modernair®

SERIES M PROVENAIR CYLINDER



Check these important new features...

1. Hard chrome plated steel piston rods with rod flats.
2. Metallic rod wiper, with automatic compensation for wear.
3. INTERCHANGEABLE MOUNTINGS.

4. Cushions "now or later"—to add cushions, simply remove plug and insert cushion needle valve; **no cylinder disassembly required.**
5. Threaded heads with "O" ring static seals may be rotated 360° for convenience in piping, installation.
6. ADJUST-O-STROKE feature (pat. pend.) on 2", 3" and 4" bore sizes permits stroke adjustment in increments of 1/16" by simply adding or removing spacers. Total adjustment is ⅞". 6" bore cylinders manufactured to stroke length required.
7. Wide-sectioned aluminum piston for increased bearing stability.
8. Removable spacer for installation of mounting bracket.

New Series M Provenair cylinders are available in 2", 3", 4" and 6" bore sizes for air or hydraulic service to 200 psi. Lip-type packing, rod boots and cushion kit accessories available. Options include oversize rods, extended rod glands, adjustable rod glands, stop-tube piston construction, double-ended rods, rod extensions, special rod threading.

See your phone book yellow pages for your nearest Modernair dealer, or write to us for catalog, price list.

Modernair® **CORPORATION**

400 Preda Street • SAN LEANDRO, CALIFORNIA • Phone: LOckhaven 2-6485
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MEMBER NATIONAL FLUID POWER ASSOCIATION

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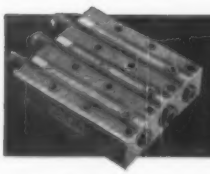
for DEPENDABLE HYDRAULIC PRESSURE CONTROL

Low price and high quality make FULFLO piston-type hydraulic valves a natural O.E.M. choice. The service they deliver . . . quiet, dependable and trouble-free . . . makes them ideal from the equipment users' viewpoint.

- **Screw or flange models . . . to 500 lbs. . . . for pipe sizes to 3"**
- **Steel, cast iron or brass bodies . . . brass, steel or stainless trim**
- **Fast shipment of standards . . . specials to your requirements**



NEED A "Special"?

FULFLO can engineer a special valve to your most exacting requirements. Examples of "specials" are shown in Data Book.

FOR EXTRA CONTROL CONVENIENCE

Request new, illustrated catalog of FULFLO Hand Wheel Valves . . . used where frequent pressure setting is needed.

Request complete catalog from:

The FULFLO SPECIALTIES CO., Inc.

415 Fancy Ave., Blanchester, Ohio

Circle **51** on Reader-Service Card

FORUM

As an improvement I would like to see all fire-resistant fluids standardized by viscosity and viscosity index and their lubricity correlated with petroleum fluids.

JOHN P. SHARP
Regional Sales Manager
Hydraulic Pump & Control Sales
Denison Engineering Division
American Brake Shoe Company
Chicago, Illinois

• ***Are you using straight-thread tube and hose fittings? Do these seal with an O-ring or a metal-to-metal fit? What are the advantages you've gotten with them? If you are not using them now, are you planning to in the future?***

We are using straight-thread tube and hose fittings which seal with a metal-to-metal fit. (Standard AN fittings). The advantages that we have found are ease of installation and reasonable service life.

G. R. LAY
Design Engineer
McDonnell Aircraft Co.
Ferguson 35, Mo.

We are using straight-thread fittings that seal with O-rings. Less torque required and less damage to components. With high temperature required of course we use metal-to-metal fit with metal O-ring seals.

T. GOTTLIEB
Project Engineer
Loud Machine Works
Pomona, Calif.

• ***Cylinder manufacturers are working toward standardized cylinder mountings. Would standardization be helpful to you?***

In my opinion, standardization of cylinder mounting would have at least three distinct advantages. First, for the designer, a cylinder of a certain type and size would always have the same mounting dimensions. This would make a number of sources available for

Continued on page 22

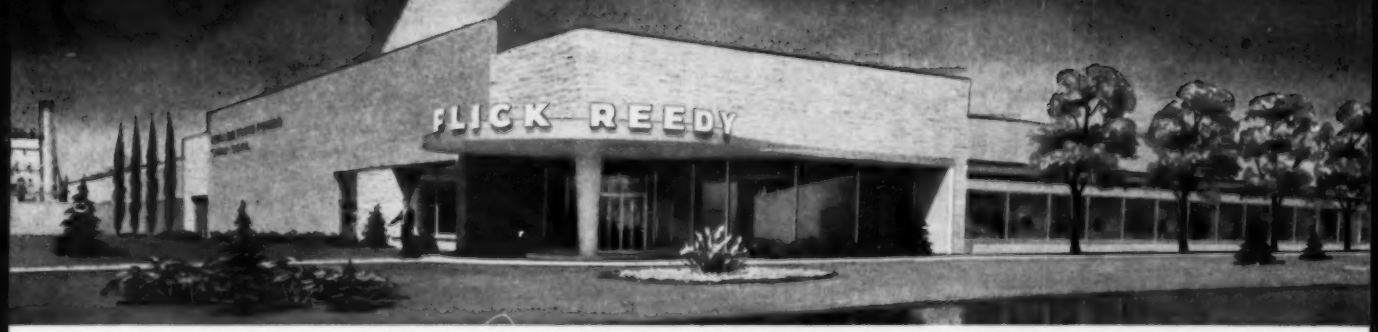
Circle 87 →

OPENING NEW HORIZONS

. . . in economical power application

98% PLUS OPERATING EFFICIENCY
MORE POWER PER CYLINDER DOLLAR
PROVEN LEAKPROOF OPERATION
GREATEST SELECTION EVER OFFERED
SAFE UNDER SEVERE LOADS
SAFE WITH ALL KNOWN HYDRAULIC FLUIDS
SAFE UNDER TEMPERATURE EXTREMES
DAMAGE-PROOF PISTON RODS

ler
HYDRAULIC
CYLINDERS



Flick-Reedy . . . *Winner of "Plant of the Year" Award and "Silver Anvil" Public Relations Award*

Miller

MORE SAVINGS!

Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an **extra 10% price savings** on our big "stock" selection of:
Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
Model "J" (Hyd.) Cylinders, 1½" through 14" bores;
Model "A" (Air) Cylinders, 1½" through 14" bores.
Strokes up to 36", cushioned and non-cushioned.

Full Details On Request

Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shef" Tubing End Seals, and other exclusive *standard* features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to *exceed* J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

Write for literature.

R

MILLER FLUID POWER
DIVISION OF FLICK-REEDY CORPORATION
7N017 York Road, Bensenville, Illinois
AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

it's DELRIN*

Another RB&W development from Delrin plastic, this new threaded plug replaces more expensive metal plugs in many hydraulic and compressor applications.

It not only saves on cost and weight, but also does a better job. Fluid pressure forces mating threads together, creates a still tighter seal, locks threads in place.

Metal-like mechanical properties of Delrin provide excellent strength, dimensional stability, rigidity. Count also on resistance to corrosion and solvents.

Available in ⅛, ¼, ⅜, ½" pipe sizes. Send for samples.

Ask about other parts you would like custom-molded from Delrin, or other thermoplastics, in production quantities.

Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*DuPont trademark

R B&W
116th year

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FORUM

his particular design. Secondly, the availability of the cylinder in case of emergency replacement. Here again the customer would have a larger selection of replacement cylinders. Thirdly, from the manufacturer's standpoint, he is able to supply replacement cylinders regardless of the original design.

ROBERT CARPENTER
Hydraulic Designer
AC Spark Plug Div.
General Motors Corp.
Flint, Michigan

Yes, standardization would be helpful when obtaining competitive quotes and when replacing worn units which now require mounting rearrangement and rework.

HARRY J. HANLON
Linder Industrial Engineering Co.
Lakeland, Florida

• What is your preference for cylinder packing (dynamic) for pistons and rods? O-rings, U-rings, V-rings, cups, flanges, piston rings, etc? Why? What problems have you had with packing? Material, size, shape, supply, leakage, etc?

I have used V-rings for higher pressures because they offer more bearing support. Also I have used square rings with quite a degree of success in sealing rods for zero leakage requirements. They do a better job than O-rings and back-up washers.

A. J. KEIR
Pippin Construction Co.
Springfield, Mass.

A preference for dynamic cylinder packing for pistons and rods depends on conditions such as stroke length, velocity, pressure, fluid, fluid temperature, contamination, permissible across seal leakage rates, and allowable load loss due to packing friction. However, I would place packings in two basic categories: High temperature (above 400 F) and low temperature (below 400 F).

For low temperature applications my preference is a standard O-ring with a Teflon cap for both the piston and rod seal. The O-ring simply acts as a spring which presses the Teflon cap against the sliding surface. Teflon against metal offers a low coefficient of friction which results in long life. This combination eliminates O-ring rolling which usually results in failure from spiral fatigue.

For high temperature work my preference for piston seals has been metallic piston rings and for shaft seals, a pressure drop bushing backed up by a series of high temperature (800 F to 1200 F) packings.

Metallic piston rings afford excellent wear characteristics and a fairly positive seal. To further enhance a bushing as a seal sometimes a rod ring in the bushing is employed. This bushing backed up by four V-packings has proven to this writer a very effective seal for any pressure or temperature.

Problems associated with various dynamic packings:

1. O-rings and square rings exhibit nibbling (alleviated by the use of back-up rings), spiral fatigue, rolling, and breakdown due to poor material quality control.
2. Teflon piston rings with an expander spring are troubled by contamination, such as metal, sand, etc. which embeds itself into the sides of the rings where, if enough contamination is present, it creates high friction between the side of the ring and the ring gland. This frictional force can become higher than the spring force resulting in the ring being permanently depressed in the gland and hence not seal.
3. High temperature V-packings which lack an adequate percentage and dispersion of metal (steel), lack the necessary resilience to compensate for temperature and wear effects.

WILLIAM K. CULICK
General Electric Co.
Evendale, Ohio

Circle 126 →

Sundstrand remote power transmission ...a "cool" idea for a coach builder

If *you* have a tough power transmission problem, perhaps you can profit from the experience of a leading transit coach builder.

When poor cooling efficiency and high noise level made it necessary to relocate the condenser for a coach air conditioning system, lack of space posed a real problem. Company engineers had to devise a compact means for transmitting power to the condenser fan (moved to the top of the coach).

Working with Sundstrand engineers, the coach builder solved the problem by mounting a Sundstrand pump under the coach on the compressor and connecting it—with small-diameter hydraulic lines—to a compact hydraulic motor directly powering the condenser fan.

The pump in this system converts variable input speed from the bus engine to constant rpm at the condenser fan motor. By continuously measuring its own output, the pump automatically assures a constant volume of fluid to the motor, regardless of bus speed.

The small-diameter motor easily fits inside the fan hub, does not disturb air flow through the fan and/or the condenser. Cool, quiet operation of the motor ends heat problems, increases condenser efficiency, and substantially reduces noise inside the coach.

Standard Sundstrand hydraulic components can be arranged in other ways to meet a variety of power transmission requirements. Other operating characteristics available with standard Sundstrand components include: automatic torque multiplication; infinitely variable speed control; variable speed output from a constant speed; automatic matching of power output to load requirements; and single-lever control of start, stop, forward, and reverse speed.

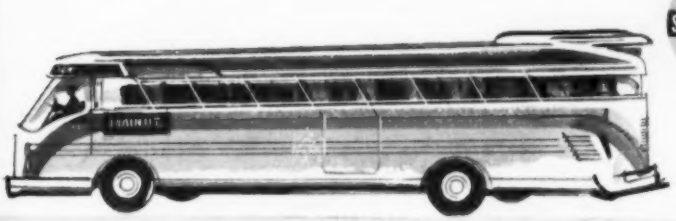
Manufacturers in five fields are now applying the exclusive benefits of hydraulic power to their equipment *economically*. Modern Sundstrand hydraulic power transmission systems can be the solution to *your* power transmission problems. Write, outlining your requirements, to Mr. Ray Murphy, *Application Engineer*.

SUNDSTRAND

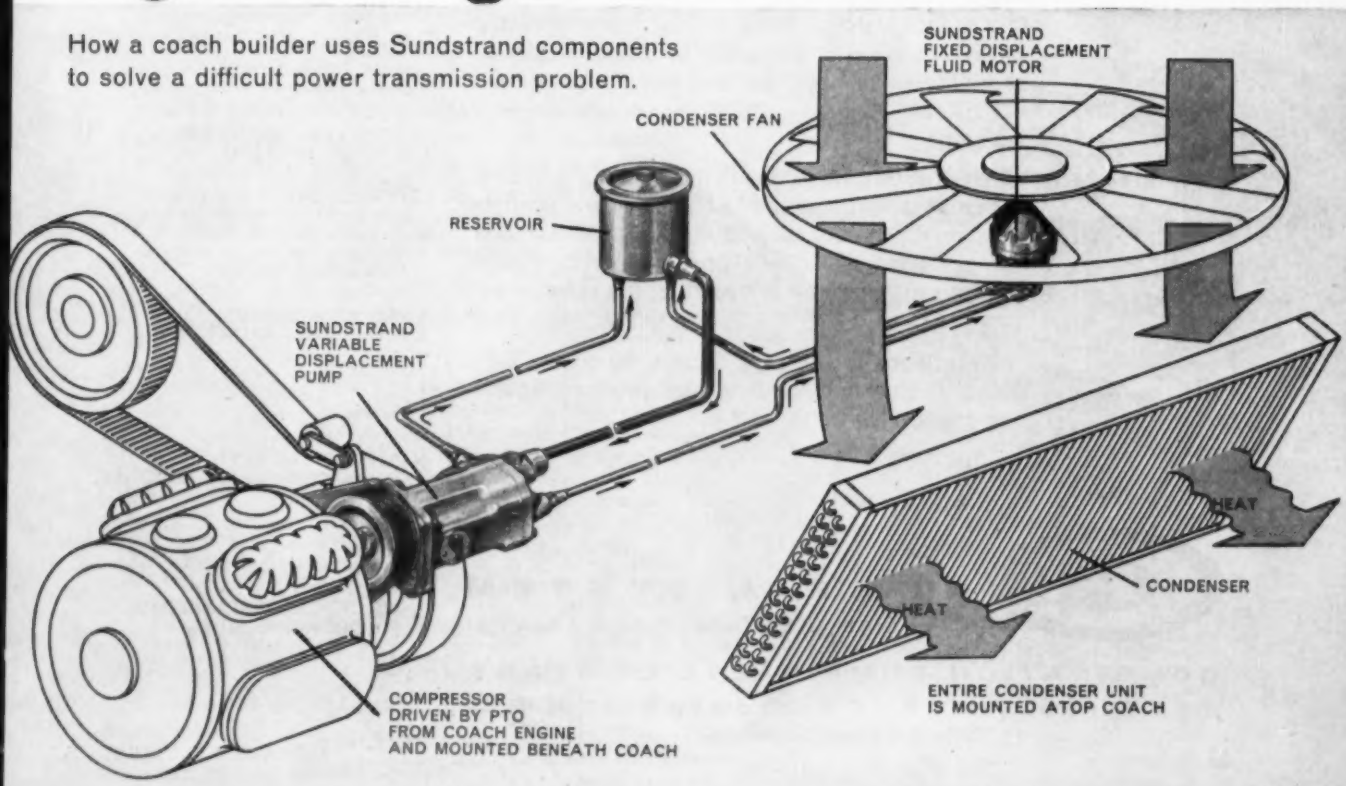
SUNDSTRAND HYDRAULICS

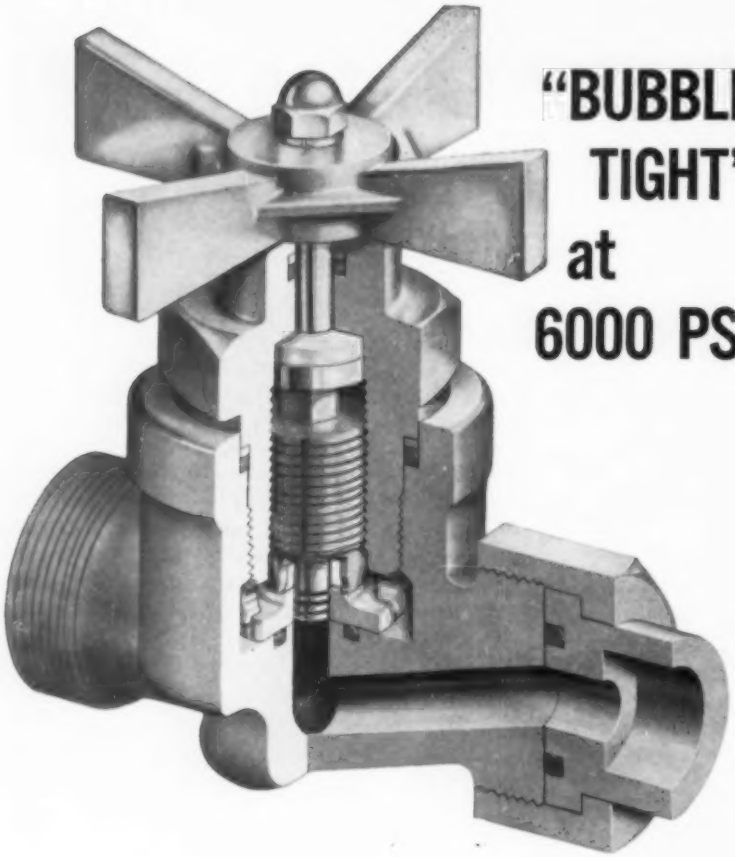
DIVISION OF SUNDSTRAND CORPORATION

2210 Harrison Avenue · Rockford, Illinois



How a coach builder uses Sundstrand components to solve a difficult power transmission problem.





"BUBBLE TIGHT" at 6000 PSI

"Bubble-tight" shut-off of high pressure liquids and gases—**even helium**—is assured every time with CPV O-Seal Valves. These unique, hand operated valves are the best guarantee of leakproof service at pressures to 6000 psi and temperatures from —20°F. to 275°F.

Get the full story. Learn how the CPV O-Seal design **uses** line pressure to obtain a tight, positive seal around the bonnet and end connections. See how easily valves can be slipped into position without springing the line or distorting the valve.

Write today for 36-page Catalog 60 on the CPV O-Seal System for handling high pressure liquids and gases.

CPV

O-SEAL SYSTEM

VALVES & FITTINGS—1500 & 6000 PSI

COMBINATION PUMP VALVE COMPANY

851 Preston St., Philadelphia 4, Pa.

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FUTURE EVENTS

SAE INTERNATIONAL CONGRESS & EXPOSITION OF AUTOMOTIVE ENGINEERING

January 9-13

Cobo Hall, Detroit

PLANT MAINTENANCE & ENGINEERING SHOW

January 23-26

International Amphitheatre
Chicago

ASME AVIATION CONFERENCE

March 12-16

Statler Hilton Hotel
Los Angeles

SAE NATIONAL AERONAUTIC MEETING

April 4-7

Hotel Commodore
New York

ASME MAINTENANCE & PLANT ENGINEERING CONFERENCE

April 10-11

Bancroft Hotel
Worcester, Mass.

SAE A-6 COMMITTEE MEETING

(Aero-Space Hydraulic & Pneumatic Systems & Equipment)

Week of April 17

Statler Hilton Hotel
Detroit

INTERNATIONAL MEETING ON FLUID SEALING

April 17-19

Sponsored by the British Hydromechanics Research Association
Grosvenor Hall
Ashford, Kent, England

ASME PRODUCTION ENGINEERING CONFERENCE

May 10-12

Royal York Hotel
Toronto

NATIONAL FLUID POWER ASSOCIATION SPRING MEETING

May 14-17

The Greenbrier
White Sulphur Springs, W. Va.

ASME DESIGN ENGINEERING CONFERENCE & SHOW

May 22-25

Cobo Hall
Detroit

HOW TO "INCH" AN AIR CYLINDER

With this packaged Bellows Air Motor-Hydro-Check Air Cylinder power unit you can do these things:

YOU CAN STOP THE PISTON ROD TRAVEL AT ANY POINT, OR AT AS MANY POINTS AS YOU WISH

YOU CAN "INCH" IT ALONG JUST AS WITH AN ELECTRIC DRIVE

YOU CAN CHANGE THE SPEED OF THE PISTON ROD TRAVEL FROM FAST TO SLOW AND BACK

You can set it up for single cycle control or synchronize it with related elements for repeat cycling with precision accuracy. This Bellows Air Motor-Hydro-Check unit is available in standard stroke lengths up to 18" and in five bore sizes: 1¼", 1¾", 2½", 3⅝", and 4½".

Not all pneumatic applications require the range of control provided in this Bellows unit, of course. But, regardless of the type of control you require, you can obtain it in Bellows Air Motors, and usually in the form of one compact, complete, packaged unit — simple to install — doubly simple to control.

THESE BULLETINS CONTAIN THE STORY

Bulletins BM-25 and HC-602 give full details on Bellows Air Motors and Hydro-Checks and the Bellows System of Air Control. There's no charge. Write Dept. AH-1260, Bellows-Valvair, Akron 9, Ohio. In Canada, Bellows-Valvair Ltd., Toronto 18, Ontario.

Bellows-Valvair

AKRON 9, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

1125B-3

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B&W offers you:

- an electric-resistance-welded carbon steel hydraulic line tube manufactured to JIC standards under a rigid system of quality control
- a full range of tube sizes to match your hydraulic application requirements
- a hydraulic line tube that costs far less than seamless in comparable sizes

B&W Job-Matched LECTROSONIC Hydraulic Line Tubing is available through a nationwide network of district sales offices and steel service centers. And remember — matching tubes to jobs assures you the *right tube,* in the *right quantity,* at the *right time.* For more information, call your local B&W District Sales Office, or write for Bulletin T-435. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

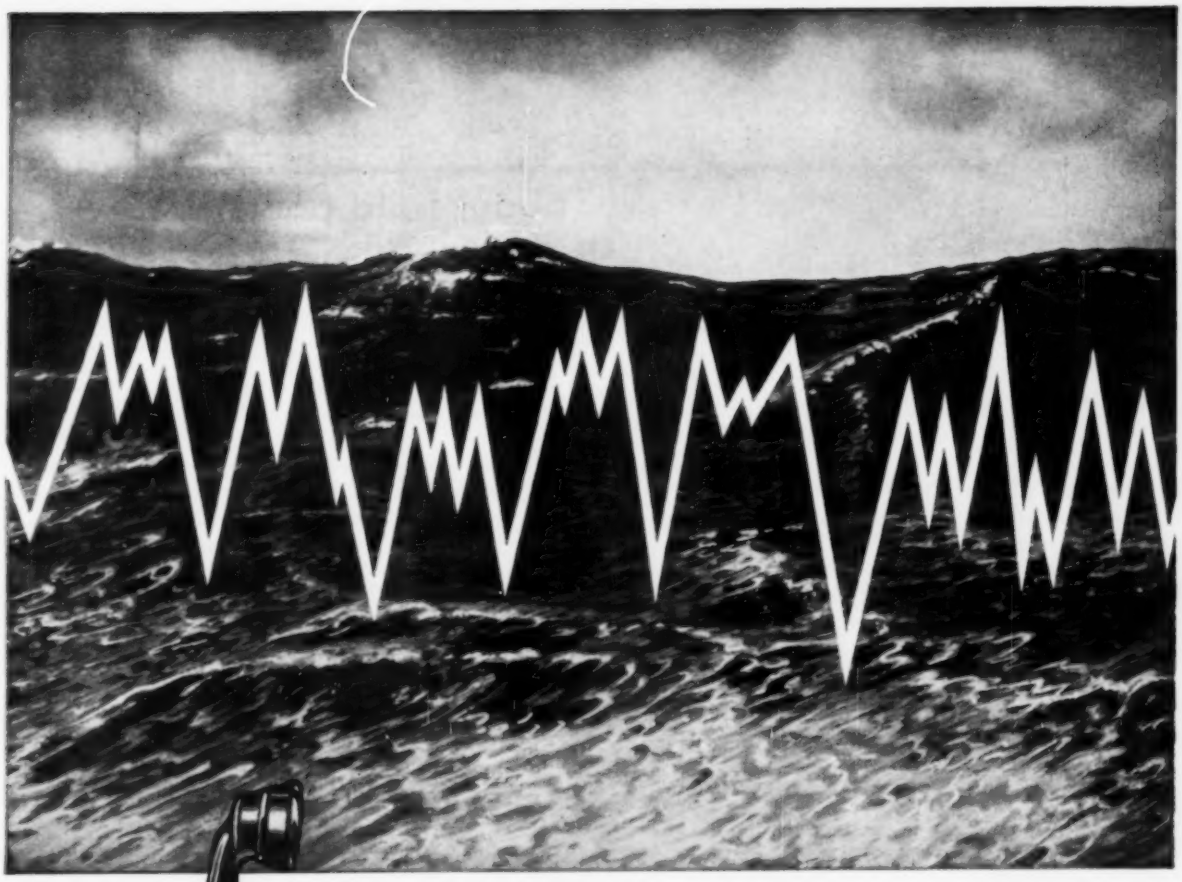
B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-9051-WM 1

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals



Telecommunications

Two recent major steps in the improvement of world telecommunications have been the laying of the first Trans-Atlantic and the California–Hawaii submarine telephone cables.

When laying cable either on a flat sea bed or over underwater mountain ranges, the exact control of paying out speed and tension in the cable is of paramount importance. 'VSG' variable delivery oil hydraulic pumps are used to act as brakes on the cable, which is drawn out of the ship by its own weight. This enables a very smooth and regulated control to be maintained or instantly varied to suit ship speed, paying out speed and tension in the cable.

It is just another of the highly varied applications of 'VSG' variable delivery pumps and transmission gears which have now been serving modern industry for over fifty years.

'VSG'

Regd Trade Mark

SERVING MODERN INDUSTRY

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BRIEFS

about fluid power

NCIH Stresses Cleanliness

CHICAGO—"Design For Cleanliness in Fluid Power Systems" was the theme for the 16th Annual National Conference on Industrial Hydraulics. Two full days (October 20th and 21st) of technical sessions were devoted to discussions of:

- Materials forming machinery
- Mobile equipment
- Servomechanisms and systems
- Missiles and space hydraulics
- Aircraft systems
- Automotive
- Hydraulic Fluids
- Components and Accessories
- Machine tools
- Pneumatics
- Pumps

Prepared papers, followed by disscusion periods, provided the means for exchanging design ideas. Such terms as "surgical cleanliness" and "white room instrumentation" were used to describe the ultimate in cleanliness demanded of fluid power components and systems.

New techniques in servovalves, and pneumatic servo steering were two of the areas covered. A method for designing a two-axis electro-hydraulic tracer system was presented and discussed.

At the opening general session, J. R. Fawcett, British designer, told of recent advances in hydraulics for mining coal in England, and Howard Zintz, director of engineering at The Rucker Co., reviewed the requirements for cleanliness in missile and ground check-out equipment, and outlined design techniques to meet them. In addition to an extensive filter system, he suggested the following for a missile check-out cart: (a) use of stainless steel wherever possible in plumbing, reservoir, and components, because stainless produces less contamination than carbon steel; (b) reduction of threads and use of manifolds; (c) heat exchangers to limit temperature; (d) Teflon lining in flexible hose (e) caps for terminal connection points not in use; and (f) capillary bleeds for pressure gages.

"All instruments, regardless of how unsophisticated they are, should be treated as delicate instruments when installed in a white room." This, according to A. V. Sada of the Weatherhead Co., Cleveland, applies to instruments for measurement and environment control.

• **SAE Particle Count**—SAE has established a reference method for determining particle count in aircraft hydraulic fluids. W. A. Riehl of Redstone Arsenal said, "Reliable results are obtained when the conditions specified in this method are closely followed."

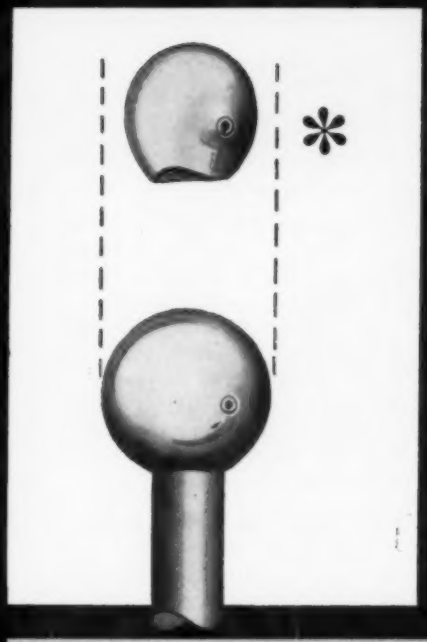
R. D. Walker of Douglas Aircraft stressed continuous bypass filtration, trained laboratory and engineering personnel, and carefully selected samples to avoid outside contamination.

Carl B. Davis and Gordon L. Wenner of The Martin Co. explained the types of contamination found in fluids. They fall into three basic catagories, solids, fluid additives, and water. Many of these

Continued on page 30

RECEIVING AWARDS for their winning entries in the HYDRAULICS & PNEUMATICS Prize Paper Contest are (l. to r.) Gil Riske, Hannifin; J. R. Crissey, Chance Vought Aircraft; and Werner Holzbock, Consulting Engineer. At right is Paul Rolnick, vice president of the Industrial Publishing Corp., who presented the awards.

Circle 70 →

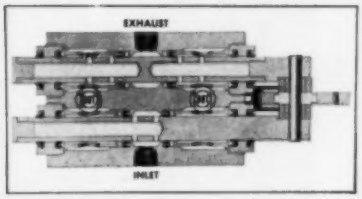


after 17 years... replacement parts

one handle ball!

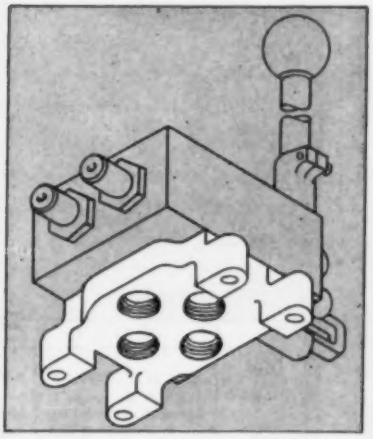
Human hands wore this metal handle ball to a fraction of its original size before the customer returned the valve to us for reconditioning. This high pressure hydraulic valve performed faithfully for nearly two decades with only such minor maintenance as replacement of "U" packing. We replaced the handle ball, repacked it, cleaned it up, and sent it back. This kind of trouble-free service is typical of Hunt hydraulic valves.

¾" MS-551-N4



The Higher the Pressure The Tighter the Seal

Cross-section view shows Hunt system of "U" packing as opposed to "metal to metal". "U" packing provides zero leakage on water hydraulic service.



Sub-Base Mounting Simplifies, Speeds Up Maintenance

New sub-base mounting is now available on all Hunt hydraulic valves. Easy, quick replacement for maintenance with no disconnecting of pipes.

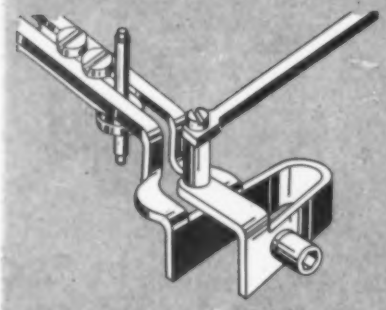
HUNT

HUNT VALVE COMPANY DIVISION OF IBEC SALEM, OHIO

Quick-As-Wink AIR & HYDRAULIC CONTROL VALVES

HEISE GAUGES

MICRO-SLIDE



Highly favorable reaction among gauge users has followed the development of the Heise Micro-Slide adjustment. Systematic field recalibration of batteries of Heise gauges may now be directly and precisely effected with minimum time loss.

Calibration adjustments as fine as .0005 inches in the effective length of the sector slide may be quickly and conveniently applied.

Periodic recalibration of gauges may also be reduced as a result of the damping effect of the spring loaded adjustment which protects the setting from shock and vibration.

CONVENIENT PRECISION RECALIBRATION

The Micro-Slide comprises a spring loaded micrometer screw controlling the position of the link pivot. This screw may be conveniently adjusted with a standard Allen wrench. A flat spring cushions the assembly and protects the setting from shock or vibration.

Dial Sizes	FULL SCALE READING (P.S.I.)						
	0-15 to 0-5,000 inclusive	Over 0-5,000 and including 0-20,000	Over 0-20,000 and including 0-30,000	0 to 40,000	0 to 50,000	0 to 75,000	0 to 100,000
8½"	$183.50	$205.50	$238.50				
12"	$209.50	$231.50	$264.50	$275.50	$286.50	$336.50	$386.50
16"	$255.50	$277.50	$310.50	$321.50	$332.50	$382.50	$432.50

DELIVERY — 2 WEEKS FOR MOST RANGES — PRICE F.O.B. NEWTOWN

Request Catalog for SPECIAL FEATURES

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

BRIEFS

contaminants enter the system during fabrication and cleaning. Others come from the environment in which the system operates.

An additional hazard with airborne hydraulic filters, discussed by H. L. Wheeler of Bendix Filter Division, is extreme vibration and g-loading. He recommended that the filter media be metallic and have extended area.

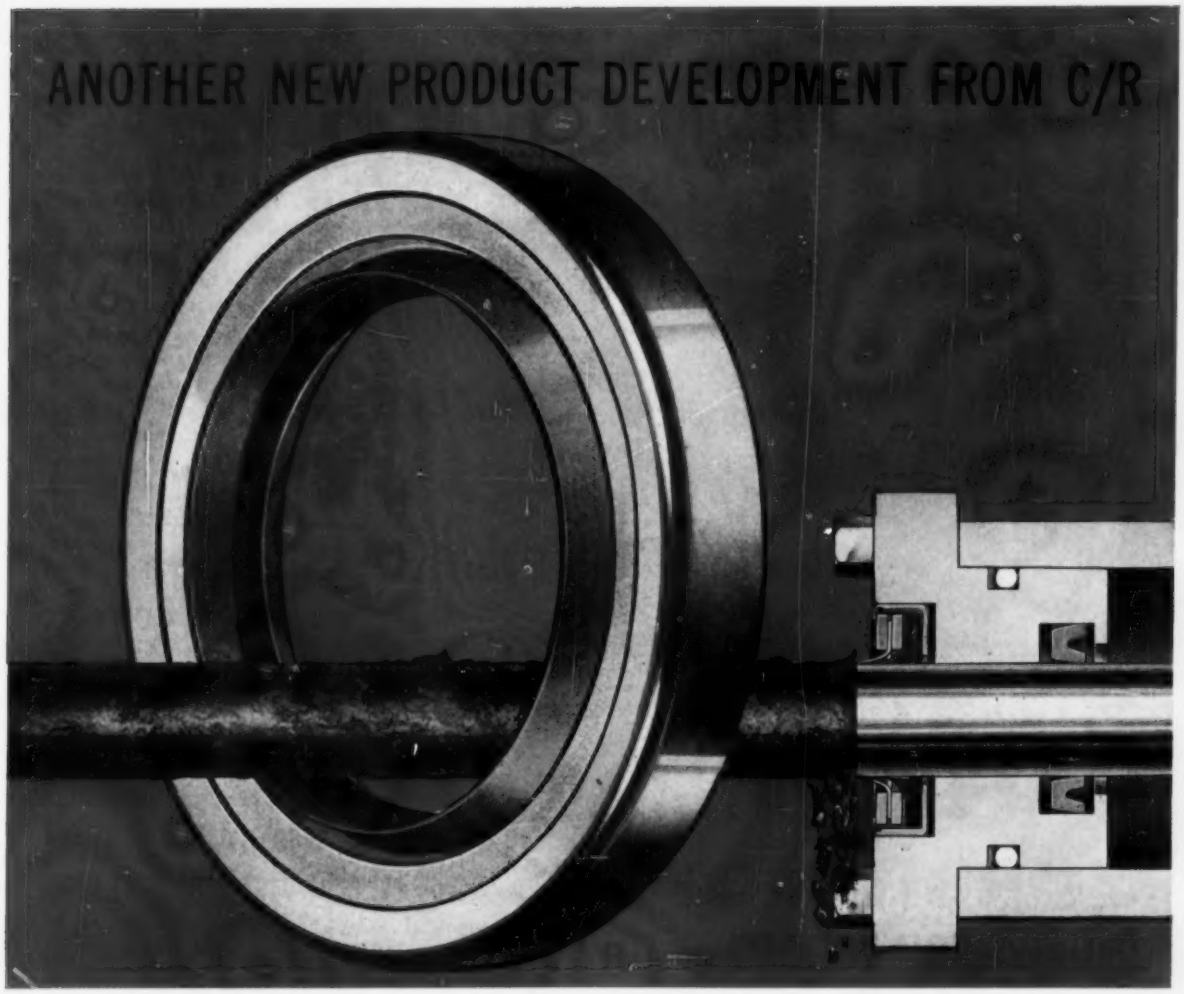
• **Foundry Air**—With the quantity of dust in atmosphere around a foundry, unusual precautions

BETWEEN SESSIONS Fred Swanson, Sundstrand; Frank Beauvais, Ford Motor; and E. W. Brennan, Pure Oil discuss the conference program.

must be taken to keep the foundry pneumatic system clean. James L. Yates, with Crane Co's. Industrial Products Group, stressed adequate suction strainers for compressors, intercoolers and aftercoolers to remove moisture.

• **Supply Oil Cleanliness**—Much of the contamination in oil hydraulic systems occurs while the system is in operation. Particles present in oil refineries are in the very low micron range according to R. Q. Sharpe, & K. G. Henrikson, Industrial Technical Div., Socony Mobil Oil Co., Inc. Servo systems involving valves with fine clearances require surgically clean oil. To obtain this degree of cleanliness, oil lines to these valves must be equipped with full flow, fine particle size filters.

Continued on page 32



New Wiper-Scraper Seal for Cylinders

Scrapes off ice, mud, tar – wipes off water, dust, other contaminants

Now, you can effectively exclude dirt and other contaminants from hydraulic cylinders under the most severe field conditions. One compact unit, the C/R SC Wiper-Scraper Seal does the job. Formerly, a separate rod scraper had to be installed in front of the ordinary wiper seal. The special machining necessary, plus the scraper ring, and retaining ring made this an expensive installation.

Chicago Rawhide's SC Wiper-Scraper Seal combines a spring brass scraper and synthetic rubber wiping member in one steel shell. The I.D. of the scraper is slightly under shaft size to provide a snug fit that will remove tar or frozen mud, but it has sufficient play within the shell to tolerate any off-center conditions of the rod such as caused by bearing "bore-slop." The cost is much lower than any other combination of scraper and wiper. "Design-in" cost is low, assembly simple. Most important is the performance contribution to the cylinder. The additional value of longer packing life and increased operating dependability with the SC Wiper-Scraper Seal will far outweigh the nominal cost.

For complete information, specifications and standard sizes, write for your copy of C/R's new Bulletin SC-100

CHICAGO RAWHIDE MANUFACTURING COMPANY

OIL SEAL DIVISION: 1203 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R Products: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts
Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.

NOW! ELIMINATE SPEED REDUCTION COST

Char-Lynn HYDRAULIC ORBIT MOTORS

Deliver HIGH TORQUE at LOW SPEED

Now you can eliminate costly and cumbersome *Speed Reducers — Save* valuable *working space — Increase efficiency — Reduce Maintenance costs* with CHAR-LYNN ORBIT MOTORS.

These Motors offer you a *new concept in fluid power mechanics* and provide a practical and economical solution to the problem of providing HIGH TORQUE — at LOW SPEEDS for Constant and Variable speed drives — Hydrostatic Transmissions and Remote Controls

- **SPEEDS from 10 to 800 R.P.M.**
- **TORQUES up to 3300 inch lbs.**
- **Starting TORQUE substantially equal to running TORQUE**
- **High Volumetric and over-all efficiency**
- **Compact and low in weight**
- **Standard mountings available**

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Minneapolis, Minnesota
PArkway 1-8761

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BRIEFS

• **Building Block Hydraulic Presses**—The same module construction used in machine tools is being used by United Engineering & Foundry in a line of hydraulic presses. Stroke length, shut height, and bed dimensions are changed by replacing standard uprights, rams, and beds. In describing the hydraulic circuit for the presses, Walter Ernst of Commonwealth Engineering stressed the efficiency of the circuit. A modified sequence valve shifts the ram from fast to slow pressing speed. The modification increases the valves speed and reduces the throttling effect and power loss during ram speed changeover.

5th annual DESIGNERS' GUIDE ISSUE

It provides Quick Guides to Product Selection . . . and a Fluid Power Products Review

JANUARY 1961

• **Need Bigger Pumps for Extrusion Presses**—With approximately 150 hp as the maximum size for standard hydraulic pumps, it's necessary to use multiple pump set-ups for large extrusion machines. A. J. de Matteo, consulting engineer also indicated that there was a need for better fluids for large extrusion presses. The cost of fire-resistant fluid for a 2000-hp system is high, and little has been done to develop components for water hydraulic systems.

• **Stiffer Systems**—Present day high response electrohydraulic servo systems must be stiff to control the fast, high inertia loads required. H. L. Smith, Jr., and L. H. Bernd of General Electric's Engineering Laboratory in Schenectady

Continued on page 37

Another pump problem . . . solved by **TUTHILL**

TUTHILL

pump-motor combinations add to precision, dependability of GPE electrohydraulic valve actuators

The Model 684 heavy-duty Electrohydraulic Valve Actuators produced by GPE Controls are used to position valves in response to low level DC input signals from electronic controllers, manual stations or flow or pressure transducers. Often used outdoors, they must be rugged . . . and their precision and dependability must be beyond question.

A vital component of these precision controllers is the Tuthill Series 48 close-coupled electric motor and hydraulic pump combination. Chosen primarily for their dependability, the compactness ($5\frac{7}{8}$"x$11\frac{15}{16}$"), and light weight (21 pounds) of these combinations enabled them to fit into GPE Controls' design without assembly difficulties.

Complete close-coupled selection

The Series 48 units are only one of a complete selection of Tuthill close-coupled combinations provided in three general series with capacities up to 50 gpm, for pressures to 500 psi. All units are particularly designed for applications where space is at a premium. Elimination of couplings, bases and adapters results in significant savings. Reduced weight means lower shipping costs . . . and their compactness simplifies assembly operations and lowers production costs.

Over 800 models

These close-coupled pump and motor units are but a small part of Tuthill's complete line of over 800 different standard models. In addition, Tuthill's experienced staff of application engineers will work with you in designing a special unit to precisely meet all the requirements of your particular application . . . "fit the pump to the problem."

Write today for Catalog 100 which describes the complete Tuthill line. Or, better yet, send drawings or other information on your pump application so that our engineers can indicate how Tuthill may be able to provide savings in your particular operation.

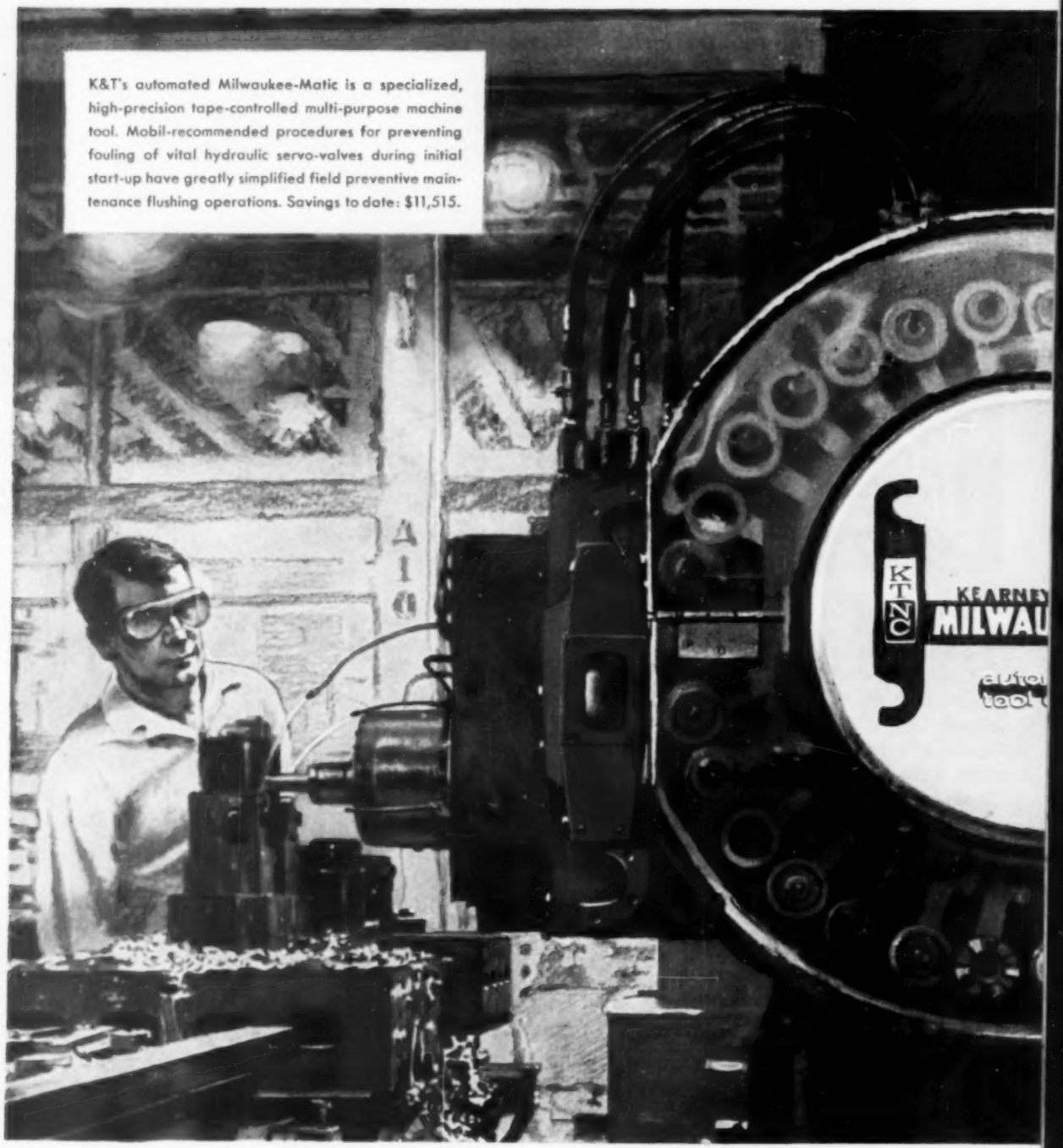
Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY

981 East 95th Street, Chicago 19, Illinois

Mobil Program produces $20,099


K&T's automated Milwaukee-Matic is a specialized, high-precision tape-controlled multi-purpose machine tool. Mobil-recommended procedures for preventing fouling of vital hydraulic servo-valves during initial start-up have greatly simplified field preventive maintenance flushing operations. Savings to date: $11,515.
KTNC
KEARNEY
MILWAU

Mobil

savings for Kearney & Trecker

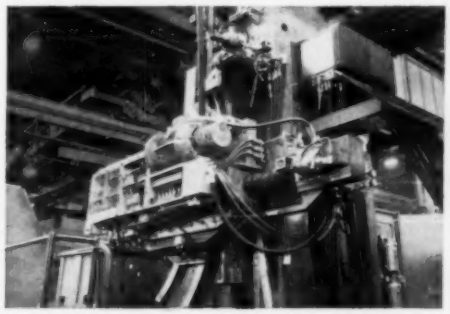
Reduces oil costs . . . promotes effective PM procedures . . . produces production economies in building of K&T special tape-controlled machinery

Kearney & Trecker is a major producer of numerically controlled precision machines, including skin mills, profilers—and the exciting new Milwaukee-Matic, a tape-controlled machine tool which can automatically perform a wide variety of complex machining operations on a given workpiece with a single setup.

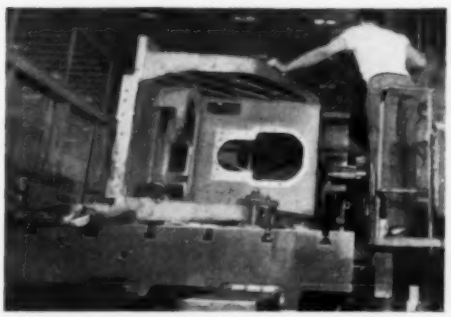
Long a subscriber to the Mobil approach to Correct Lubrication, K&T has relied on a Mobil Program through the 7 years of operation of its Special Machinery Division plant. Close cooperation and liaison between Mobil and K&T personnel have resulted in a minimum of downtime, rock-bottom lubrication costs, and improved maintenance, manufacturing and production efficiencies. Dollar savings at K&T to date total $20,099 . . . just one indication of the success of the Mobil Program.

For information on how a Mobil Program might benefit you, call your Mobil Representative or write: Mobil Oil Company, 150 East 42nd Street, New York 17, New York.

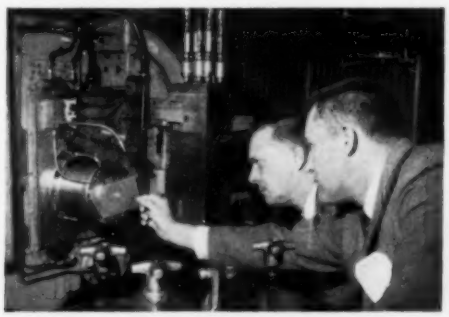
To assure clean hydraulic systems and correct operation of servo-valves, K&T uses large quantities of hydraulic oil to test-operate its special machinery prior to shipment. Previous practice had been to discard all oils after a single use. At Mobil's recommendation, these oils are now filtered and re-used for preliminary flushing operations. Savings to K&T: $4,631 in 1959.



In manufacturing Profilers, K&T planned to remove loose mill scale from hydraulic piping by dismantling parts and pickling them. At Mobil's recommendation, piping was left intact, and each unit was flushed with a specially formulated hydraulic oil. This dissolved binder material permitting effective removal of dirt and scale—with resultant savings of $3,953.



A Mobil-recommended preventive maintenance procedure for correct lubrication on this $300,000 horizontal boring mill prevented a recurrence of a $2,550 repair bill previously caused by lack of lubrication.



When the mist lubricating unit in K&T's Milwaukee-Matic produced a dense migrating oil fog, Mobil was asked for a solution. Next morning K&T had it. A special Mobil oil in the micro-fog unit eliminated objectionable fog.

Correct Lubrication

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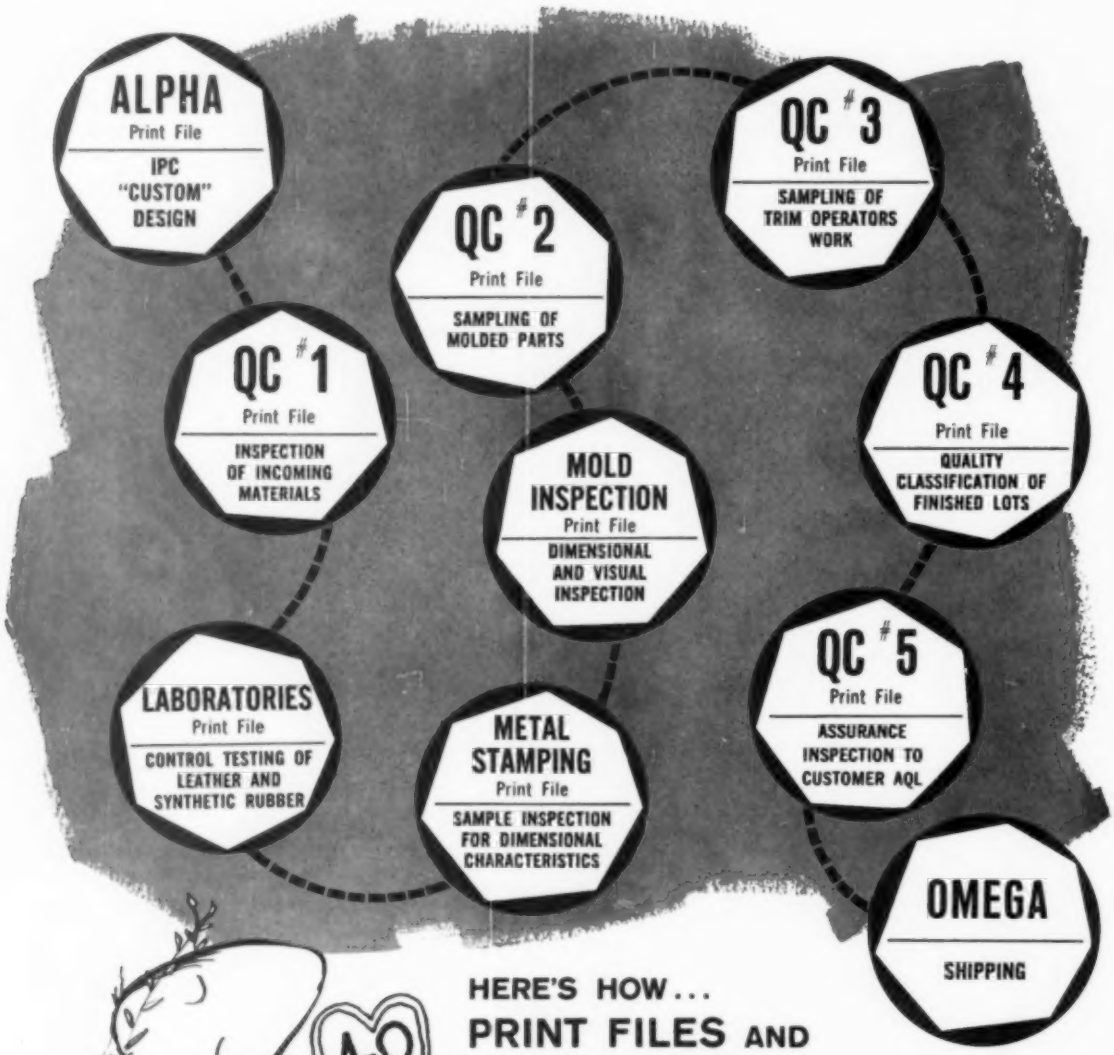

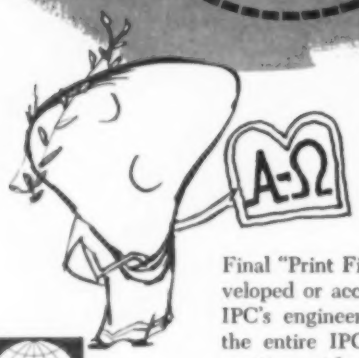

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BRIEFS

said considerable information is available on bulk modulus for low molecular weight compounds, but a need exists for more information on higher molecular weight fluids used in industrial hydraulic systems today.

Using liquid metal for hydraulic fluid is the answer to high temperature hydraulics offered by R. C. Kumpitsch and J. R. Granan of the Armament Control Section at General Electric. NaK-77 remains liquid from 10 to 1400 F, and according to tests behaves in a predictable manner.

• **Better Shaft Seals**—Both R. O. Isenbarger of Chicago Rawhide and R. L. Dega of General Motors agreed that the most compatible surface finish for shafts being sealed is 10 to 20 micro-inches. A finish of less than 10 micro-inches will not retain the thin film of oil needed to lubricate the seal. Isenbarger said the shaft being sealed should have a hardness between 45 and 60 Rockwell C for best seal wear life. ▼▼▼

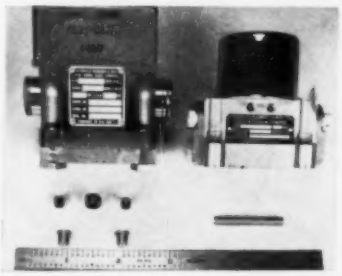
Miniature Filters for Servovalves

Maintaining dirt-free hydraulic fluid is particularly important and sometimes most difficult to achieve in servovalve systems. Engineers at Hydraulic Research and Manufacturing Co., Burbank, Calif., chose a special, wound-wire filter from Bendix Filter Div. to help keep their servovalves clean.

Contamination in a servovalve orifice or nozzle unbalances pilot pressure and produces an output that does not reflect input. Dirt between the spool and sleeve creates friction.

There are two major types of contamination—silting and extremely fine fibers. Silting is the accumulation of very minute particles, considerably smaller than the filter rated pore size. These particles collect downstream of the filter and in the servovalve. Individually they are too small to cause trouble. But silt build-up can be as detrimental to orifice, nozzle, and spool operation as large particles. Sufficient silting in the sleeve can eventually stop spool movement entirely.

Fiber contamination presents a different problem. Filter pores are essentially two-dimensional. Extremely fine fibers are often hundreds of times longer than their diameters. When the diameter of such a fiber is smaller than the pore size, the fiber in some types of filters can snake its way



through the filter. Such contaminants are as harmful as particles which are too large to pass through the filter. If the fibers reach the first stage orifice, they collect silt, and eventually plug the orifice.

• **Filter Construction**—The wound-wire filter is made by winding fine, flattened wire (as small as .001″ dia.) on a mandrel. A rotational accuracy of one part in 10,000,000 can be achieved for extremely accurate pore size control. Different winding patterns determine the pore sizes. The number of layers of wire (which can vary from 4 to 30) controls the filter permeability.

The filters used in the Hydraulic Research servovalves are made from 18-8 series stainless steel, which is compatible with many corrosive fluids and adds a minimum of contamination to the hydraulic system itself.

The filters are sintered in special furnaces in an atmosphere of pure dry hydrogen. This bonds all crossing wires at each contact point. Bonding adds strength to the filter wire structure and eliminates any media slough-off or migration into the hydraulic flow stream.

Continued on next page

AIR He N

COMPRESSION to 12,000 psi

...discharge capacities to 150 scfm

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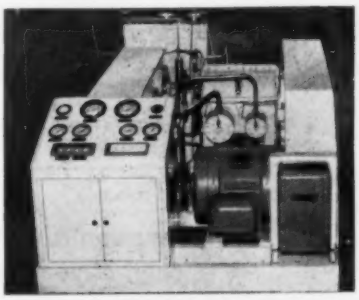

Model PB-CCS—*One of a wide selection of systems* 4-stage air-cooled Compression System—Pressure Range: 6,000—12,000 psig—Induction: 65 to 135 psig—Capacity: 75 scfm N₂ and Air; 70 scfm He—Guaranteed Gas Purity: —100°F. Dew Point, less than 4 ppm oil content.

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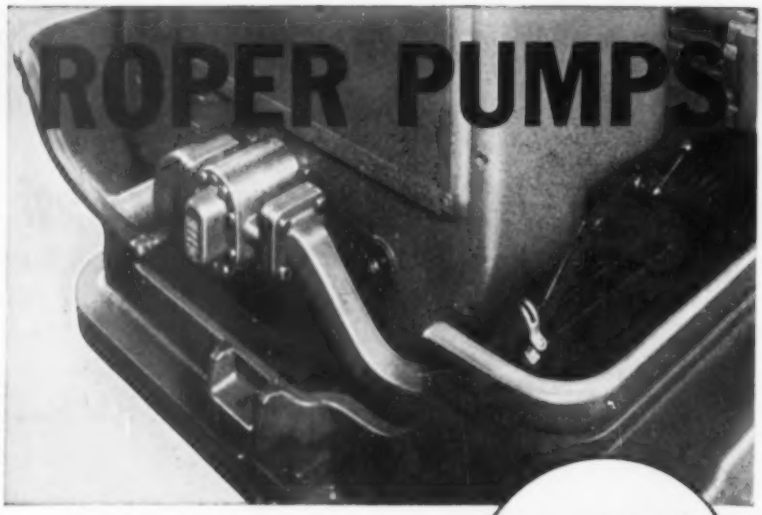

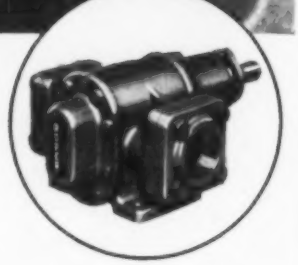

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BRIEFS

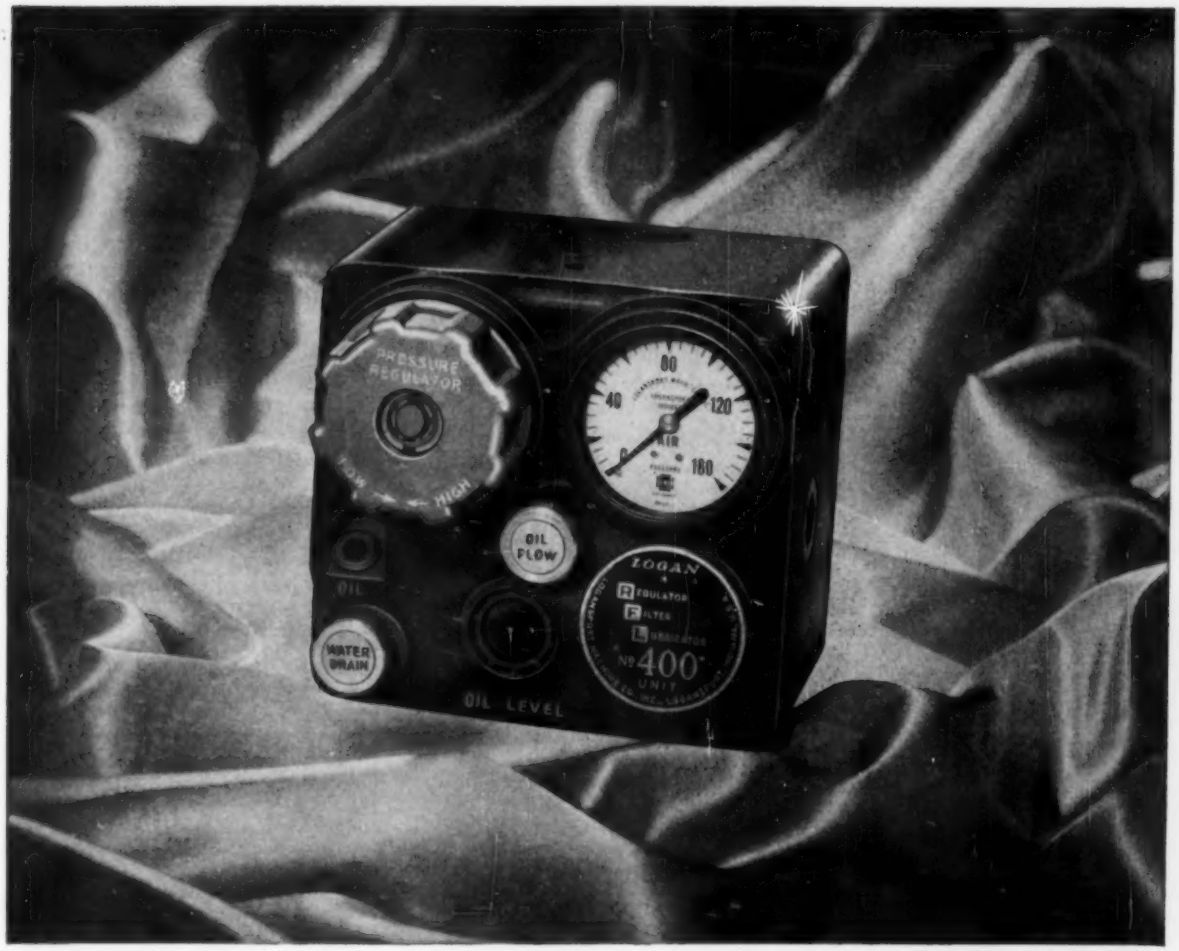
The filters protect a .005" diameter orifice. Pressures at the orifice filter reach 4,000 psi. The filter has a filtration area of .11 sq. in. and can handle up to .1 gpm. The filter structure is self-supporting, and requires neither integral end plates nor stiffeners. Because of its cylindrical, continuous winding design, there are no welded or brazed seams to decrease its effective filtering area. This is important where miniature filters are placed in confined areas. ▼▼▼

Servovalves Help Launch Nuclear-Carrier Jets

Four catapults will launch jet fighters from the deck of the Enterprise, first United States nuclear-powered aircraft carrier. Electrohydraulic valves developed by Sanders Associates, Inc., Nashua, N. H., will position the control valves used to meter the

Continued on page 40

TO SAVE WEIGHT, containers for storing 5000-psi air are being made of fiberglass yarns impregnated in an epoxy resin bath with a hardner to give toughness and heat resistance. The containers are wound into layers of strands on a rubber lined mandrel. After winding, the sphere is heat cured. Weight reduction from steel construction is 35%. Smooth-On Mfg. Co., Jersey City, developed the hardener for Walter Kidde Co., Belleville, N. J.



Illustrated—Logan Model 400 RFL Unit

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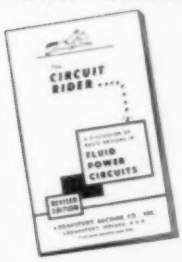
New Model 400, illustrated above, is a companion model to the well-known Model 600.



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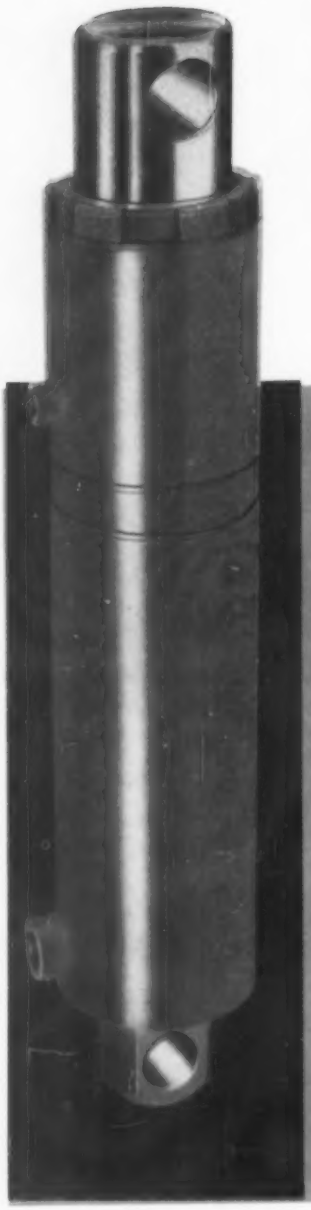

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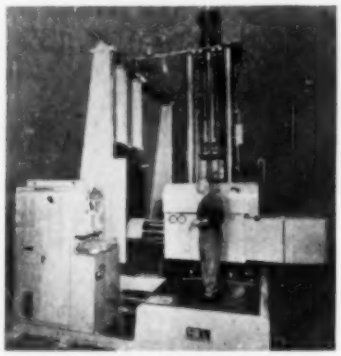
BRIEFS

fuel-water-air mixture in the catapult powerplant. Hot gases release greater energy than steam (commonly used to power Navy catapults) under the same conditions. The expanding gas method of catapult propulsion was therefore chosen to launch the heavier, faster, carrier- based jet fighters.

This system offers considerably faster dynamic response than electric or pneumatic systems requiring more than one horsepower at the load. The response comes from (1) the actuator's high torque-to-inertia-ratio, (2) the actuator's large power-to-weight and power-to-volume ratios, and (3) the electrohydraulic servovalve's wide bandwidth and power handling capacity. The basic function of the



NUMERICALLY CONTROLLED jig drilling machine, drills holes in parts or groups of parts measuring up to 10-ft sq. Materials can be handled on the machine by indexing the part horizontally and floating in the correct zero setting for tape programming. Hydraulic cylinders move the head vertically and horizontally. The cylinders are actuated by motor-operated worm gear and ball bearing lead screw arrangements. Machine is manufactured by Walter P. Hill, Inc., Detroit, Mich.

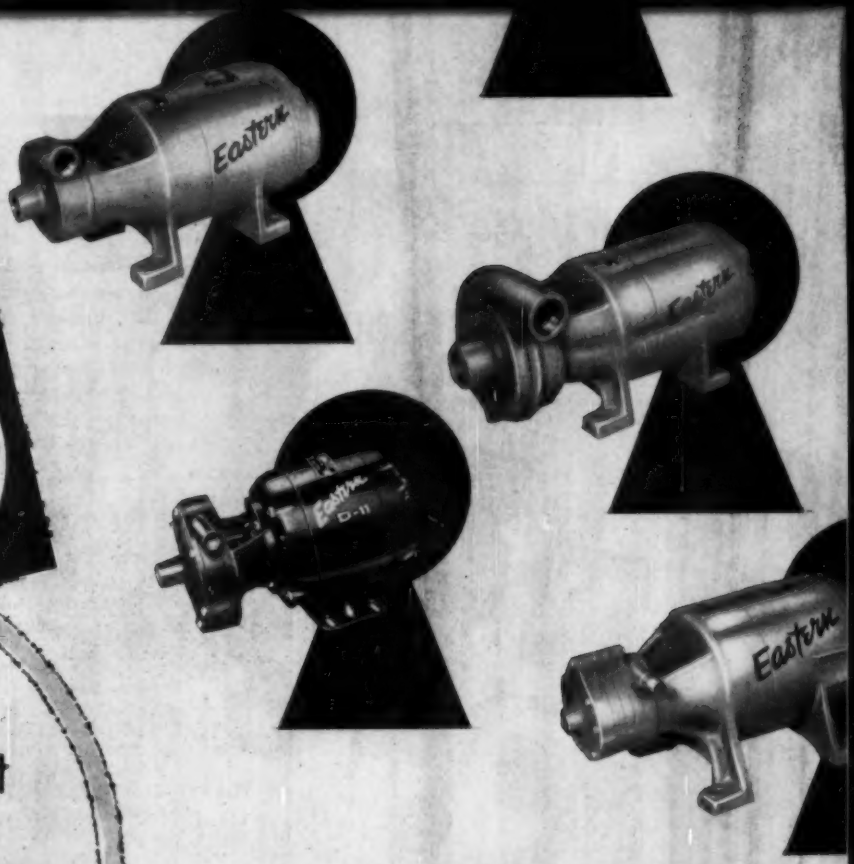
electrohydraulic servovalve is to control the large output power delivered to the actuator with a low power electrical signal. In this respect, it is anologous to an electronic power amplifier.

To achieve constant catapult and plane acceleration, throughout the run, an automatic feedback sys-

Continued on page 42

Circle 44

Eastern



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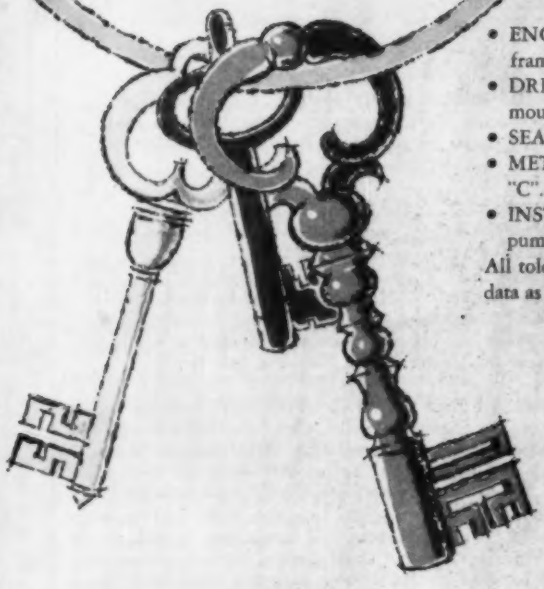

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BRIEFS

tem maintains a constant pressure in the rapidly increasing cylinder spaces. Twin, 18" diameter cylinders propel each catapult. They travel through a 243-foot stroke in 2 to 5 seconds. A water brake stops the piston at the end of the run. Initial acceleration rate change, before peak acceleration is reached, is carefully controlled to prevent excessive g-loading.

The servovalve developed for this application is a 2-stage, in-line design with spool type pilot and output stages. The filtration circuit has an integrally mounted, replaceable 2-micron magnetic filter and a 10-micron mechanical filter. ▼▼▼

More Briefs on page 44

BRIEF NOTES

THE FULLER CO. IS MOVING . . . its Los Angeles sales office, from Los Angeles, to it modern plant in Compton, Calif. The move was made to centralize Fuller's activities in the greater Los Angeles area and provide customers with more efficient sales and service.

EXPANDED TEFLON TUBING . . . which recovers its original dimensions when heated, giving a tight shrink fit is described in Bulletin 3E, available from Pennsylvania Fluorocarbon Co., Inc., Philedalphia, Pa. The bulletin describes applications of this shrinkable tubing which is made in eleven different colors.

FORMED STEEL TUBE INSTITUTE . . . new name is Welded Steel Tubing Institute. Headquartered in Cleveland, the non-profit organization promotes research and development for the steel tubing industry.

BETTER TEACHING METHODS . . . and curriculum changes in fluid mechanics were recently considered by a group of university professors. The meeting was sponsored by the University of Pennsylvania and the National Science Foundation. The group met at the U. of P., where it also discussed what constitutes a proper balance between basic theory and engineering applications in an undergraduate course in fluid mechanics.

PLASTIC AND RUBBER PRODUCTS CO. . . . has recently moved into new quarters adjacent to its present Los Angeles, Calif., facilities. The 20,000 sq ft building will provide expansion area for some production departments, and furnish additional space for equipment additions for molded rubber products.

BUSINESS BRIEFS

AMERICAN BRAKE SHOE DECLARES DIVIDEND . . . A quarterly dividend of $.60 per common share was announced by American Brake Shoe Corp., parent organization of Denison Engineering, Atchley Inc., and Kellogg Div.

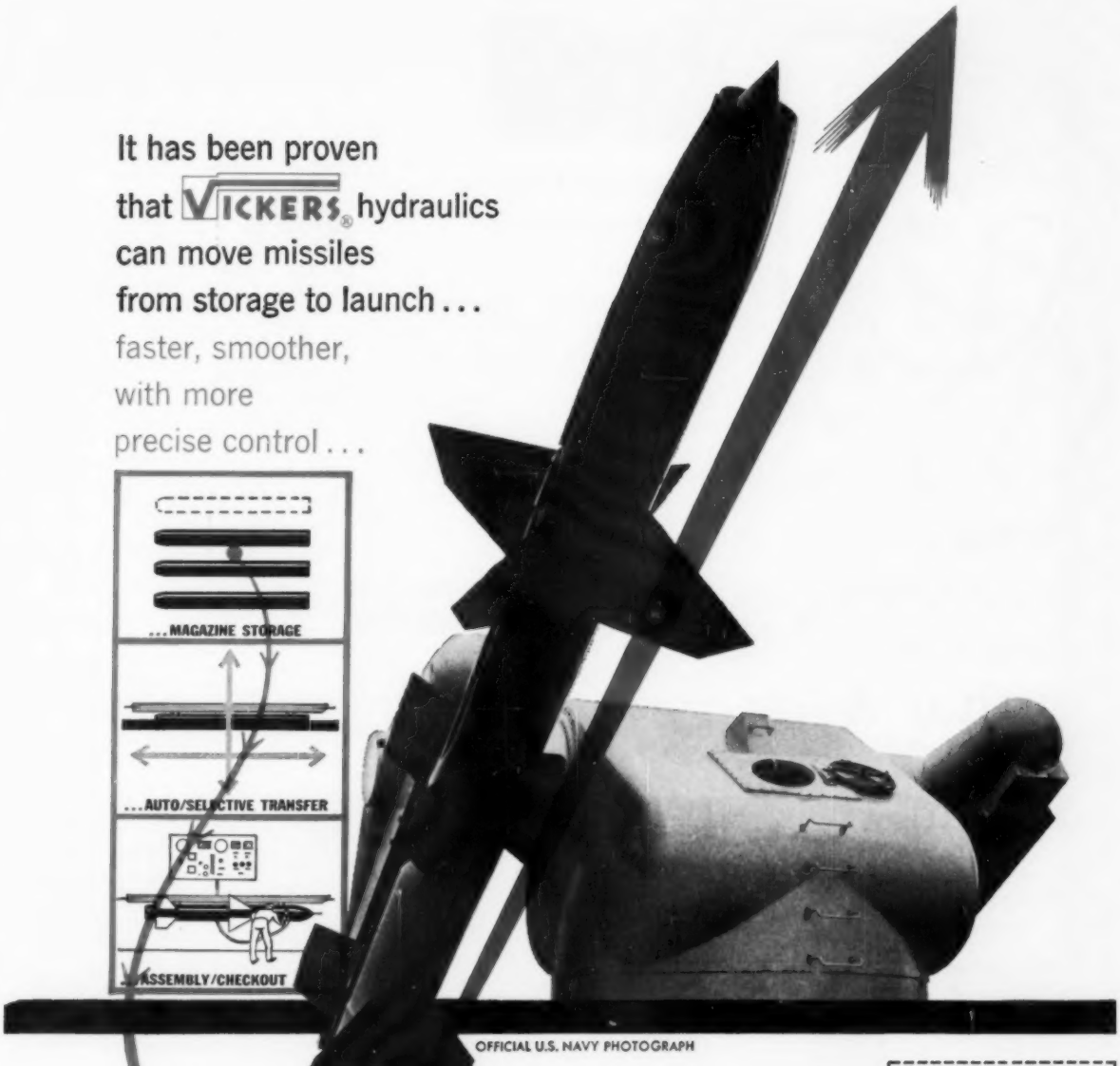
HYDRODYNE INTERESTS SOLD . . . Donaldson Co. Inc., has acquired 2/3 interest in the Hydrodyne Corp., makers of pneumatic and hydraulic handling components for missiles and rockets.

ROCHESTER MFG. CO. MERGES . . . Merger is planned by the Rochester Mfg. Co. Inc., with American Radiator & Standard Sanitary Corp., New York. The Rochester firm will continue to operate as a manufacturing facility of the Detroit Div. of American Standard.

HANSEN MFG. DECLARES EXTRA DIVIDEND . . . In addition to its regular $.15 dividend, the Hansen Mfg. Co., Cleveland, has announced an extra $.15 dividend per common share. The company makes quick-connect, fluid line couplings.

BENDIX CORPORATION . . . has become sole distributor and representative in the USA for machine tool numerical control sysmanufactured by Ferranti, Ltd. of Great Britain. Ferranti numerical controls include punched tape positioning, magnetic tape contouring and coordinate inspection systems.

It has been proven that VICKERS® hydraulics can move missiles from storage to launch . . . faster, smoother, with more precise control . . .



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Vickers has designed and built over 100,000 hydraulic servo systems for the direction and guidance of ordnance. Applications range from radar controlled anti-aircraft guns to completely automatic missile handling systems.

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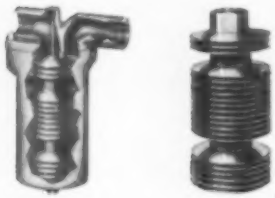
Here's a magnetic strainer with a fatal charm

Ripley magnetic Sump and Line Strainers combine magnets and screens for a positive 2-way filter trap!



Line Strainer Sump Strainer

The irresistible magnetic force of Ripley Sump and Line Strainers *attracts*—and *traps* iron and metallic particles! Non-ferrous matter is stopped by the removable filter disc screens, giving efficient, effective protection for all types of hydraulic systems. Both Sump and Line models can also be custom made for all unusual applications. Write today for complete information!

RIPLEY

SCREEN AND STRAINER CO.

Filter Division

32749 Northwestern Hwy., Farmington, Mich.

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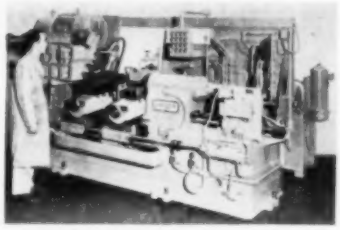
BRIEFS

Automatic Lathe Has Hydraulic Slides

This automatic lathe rough turns and faces 8 different lengths and diameters of forged steel automotive axle shafts. It has a hydraulic cylinder-operated overhead slide that provides the flange pilot turning function. A rear slide, fed by a hydraulic cylinder, straddle-faces the flange. Two pivot-mounted turning slides are at the front end of the work. Hydraulic cylinder-operated cams raise the slides into adjustable micrometer stop positions for the turning operation. Axial slide advance for turning is made by another hydraulic cylinder. Manufactured by the Snyder Corp., Detroit, Michigan. ▼▼▼



FPS News

The Fluid Power Society held its first national meeting in October. Membership is now well over 300 and six chapters are established. These photos show what's going on nationally and locally.

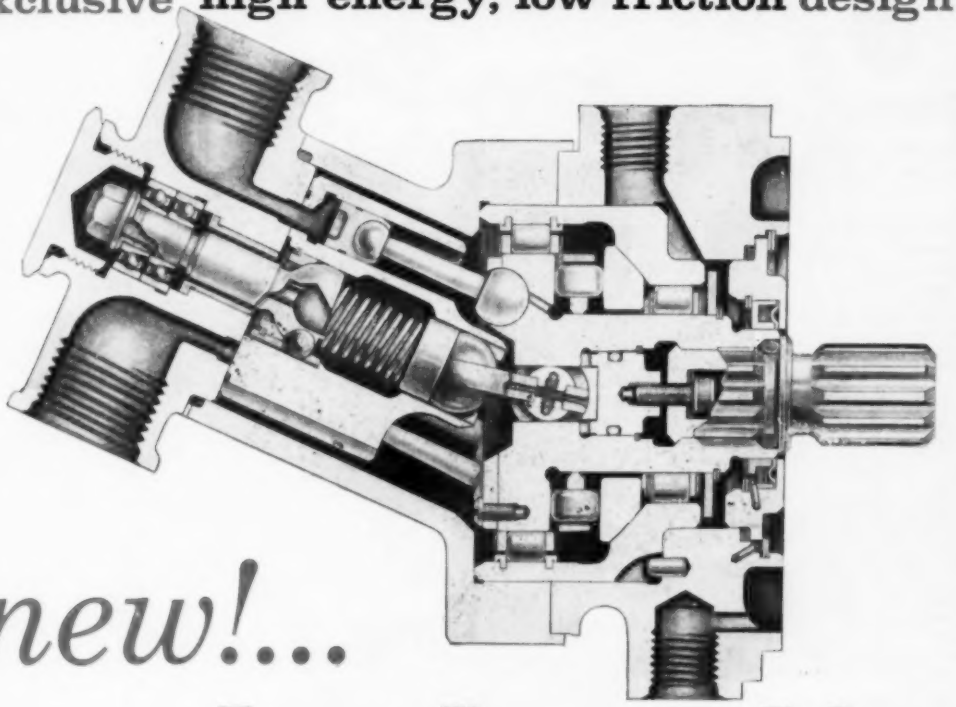
FPS BOARD OF DIRECTORS met during the annual meeting. They include Frank Mackin (president) George Altland, Walter Ernst (vice president) Lynn Charlson, Barrett Rogers (executive vice president) and Allan Morris (treasurer).

FLUID POWER SOCIETY national president, Frank Mackin, General Motors Institute, presents an organization charter to George Altland, Vickers Inc., president of the Society's Chapter No. 1—Detroit. Looking on is George Tinneti, General Motors Institute. The meeting was held in Detroit in September at the Ford Sterling Plant.

FRANK MACKIN, president of the Fluid Power Society, addressed the organization's first national meeting in Chicago in October. Barrett Rogers, executive vice president is at left.

More Briefs on page 46

exclusive **high energy, low friction design**



new!...

hydraulic
motors and pumps

with basically new design features
offering basically better performance!

Free — Product Data Bulletin No. 25 describes Cornelius Aero Hydraulics equipment; includes installation information, specifications and performance data. Write today.

Here is important news for hydraulic design engineers. The Cornelius Company is pleased to announce development of a new line of hydraulic motors and pumps that are lighter, more efficient and more compact. The exclusive, new **high energy, low friction** design of this equipment is possible because of Cornelius inventions. Nine U.S. and foreign patents covering these products have been issued to date.

If you have unsolved problems in hydraulic motors and pumps or are not entirely satisfied with the performance you are now getting from your present equipment, be sure to investigate these new Cornelius products. These new Cornelius pumps and motors can be tailored to meet your system requirements.

Pioneers in Pressure Systems for Flight

THE Cornelius COMPANY
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Qualified individuals will find excellent opportunities available in Cornelius engineering and sales departments.

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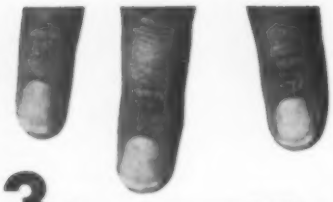


3 Reasons Why

Robbins VALVES Are the Most Economical You Can Buy

1. The only valves that can be completely serviced in less than 1 minute from the front of mounting panel without removing the valve from the line!

To service a Robbins Metering & Shut-Off Valve it is only necessary to remove the handle, loosen locknut and remove barrel assembly . . . all accomplished from the front of the panel . . . no need to disturb the line connections!

2. Single barrel assembly!

For both civilian and military installations the single barrel assembly design and construction features (barrel, spindle, spindle seals, barrel seals and seat in one unit, cleaned, lubricated, sealed for oxygen service) mean practically instantaneous renewal of service without disconnecting any plumbing.

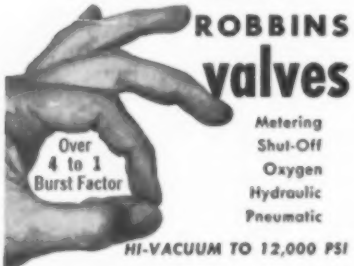
3. As many as 5000 cycles before requiring servicing!

Many Robbins Metering Valves . . . in constant use on an 8-hour a day basis for three years . . . have never required servicing, lubrication, or any parts replaced!

...And the Most Reliable!

Precision made and tested. Design capabilities, manufacturing procedures, and quality control operations at Robbins Aviation are all directed toward one objective . . . to produce a valve of the highest quality that will provide the user with the greatest reliability and the greatest economy over many years of service.

All Valves LOX Cleaned and Packaged . . . Ready for Instant Use



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ROBBINS Aviation Inc.

Write today for complete color catalog and valve technical information

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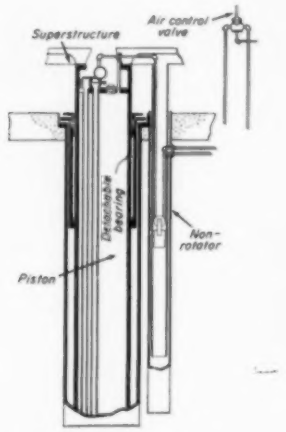
BRIEFS

PANELISTS at the Cleveland Chapter's October meeting on hydraulic filtration, were (seated l. to r.): Nils Rosaen, Rosaen Co.; Alvin Rood, Euclid Div., General Motors; William Morgan, National Acme Co.; and Gerald Snowden, Ford Motor Co. They discussed the subject from the viewpoint of a filter manufacturer, mobile equipment builder, machine tool builder, and hydraulic equipment maintenance. Chapter chairman Allan Morris, editor of Hydraulics and Pneumatics, introduced the speakers. More than 80 men attended the meeting.

CHARTER FOR THE SECOND chapter of the Fluid Power Society was granted to the Milwaukee group. Chapter officers are (l. to r.) Mel Striegel, director of the evening division, Milwaukee School of Engineering, chapter secretary; Dudley Pease, of Dynex Inc., vice-president; and Russ Henke, director of research for Racine Hydraulics & Machinery, Inc., president. Not shown is treasurer James Price of Price Engineering Co. A one-day seminar on electrohydraulic servo systems will be held on December 7 at the Allen Bradley Hall of Science in Milwaukee, by the Milwaukee School of Engineering in cooperation with the Milwaukee chapter of FPS.

Auto Lift Has Positive Air-Oil Lock

To actuate this lift, manufactured by the J. C. Cochin Mfg. Co., South San Francisco, Calif., operating air pressure is applied only at the top end of the piston. All the oil supply is contained within the casing-piston assembly. This design eliminates the vulnerable standpipe, formerly extending through the buried bottom-end of the casing to connect air pressure to the piston. An automatic release-lock mechanism at the top-end of the piston, deadlocks both air and oil systems instantly and simultaneously. This deadlock can be released only when the up-and-down control valve is actuated.



The valve is located out from under the lift. Because air pressure is required to unlatch the deadlock, even a complete air system failure cannot affect the lift positive safety locking feature. Semi-safe devices such as mechanical ratchets or safety legs are not required. ▼▼▼

Press Cycles 600 Strokes/Min

A high speed hydraulic stamping press has been announced by Denison Engineering Division, American Brake Shoe Co., Columbus, Ohio.

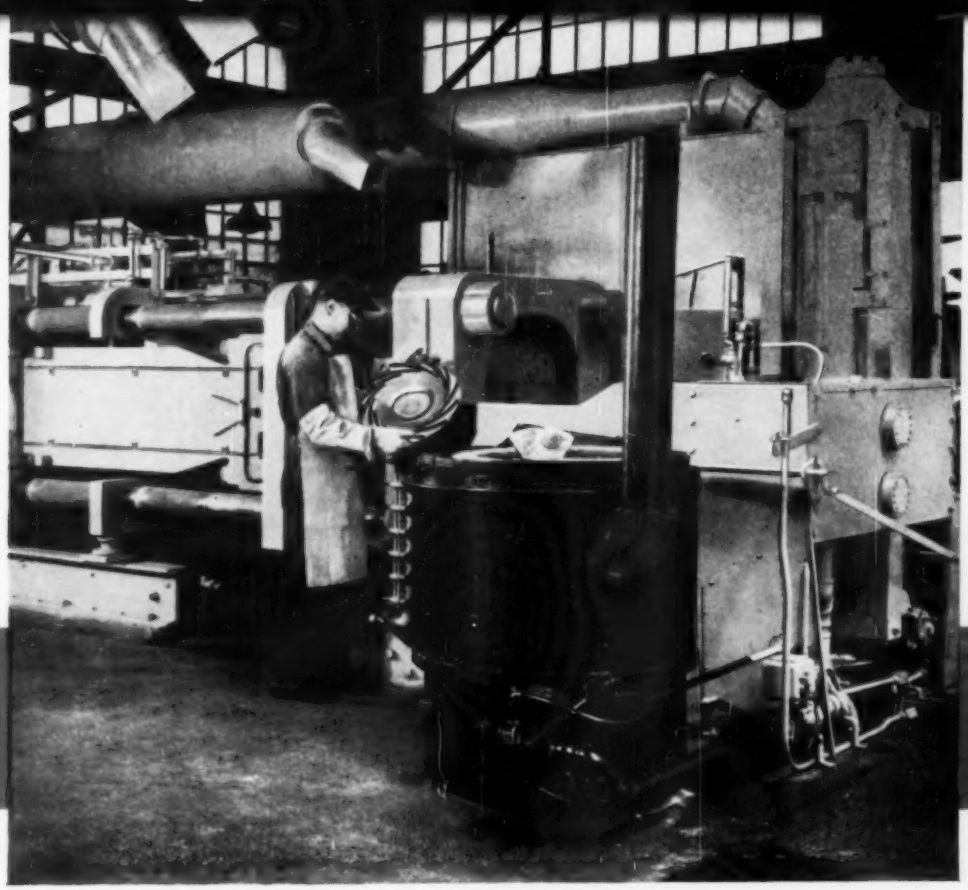
The 25-ton press has a closed-circuit hydraulic system servo drive with harmonic cam drives for work strokes from 1″ to 3″.

Operating pressures and the number of ram strokes can be changed while the machine is cycling. The servo loop system automatically sequences feed control with any change in ram stroke.

Punch break through is adjustable and controlled without positive stops. Range of punch break through is 1″, in .001″ increments. Elimination of positive

Continued on page 48

Circle 33 →



A 750-ton cold chamber die-casting machine at Alcoa's Garwood plant. Holding furnace in foreground containing molten metal is close to pressurized hydraulic lines.

Cellulubes promote safety at Alcoa

where hydraulic lines at 3500 psi pass near molten metal

The danger of fire due to line breaks has been held to a minimum at Alcoa's Garwood Works. In die-casting operations, Aluminum Company of America uses Cellulube fire-resistant hydraulic fluids in the hydraulic system serving the die-casting machines.

Although there have occasionally been line breaks under pressures ranging up to 2,000-3,500 psi, no serious fires have ever resulted. Alcoa has found that Cellulubes not only perform well as hydraulic fluids, but provide excellent lubrication of pump parts.

Cellulubes, the *safe* hydraulic fluids, are available in six controlled viscosities: 90, 150, 220, 300, 550 and 1000 SUS at 100°F. You can select the viscosity best suited to your operations. Cellulubes may well make an important contribution to the safety of your plant and personnel. Write to us for more information about Cellulubes. If you'd like a sample for evaluation, please let us know what application you have in mind.

Celanese® Cellulube®

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a Division of Celanese Corporation of America
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These RMC thermometers have just been submerged in water for the first of a severe series of tests to make sure of perfect hermetic sealing.

Moisture will never bother your RMC dial thermometer

The RMC hermetic sealing process makes absolutely certain that humid air will not be sealed in the instrument and locks all moisture out permanently. Each thermometer then goes through a series of severe tests. Only those with perfect sealing are accepted for delivery. When you order from RMC you get the *only* industrial thermometer that can *never* be affected by internal dial fogging or bimetal freeze-up.

"Bimetal Freeze-up" More Serious Than Dial Fogging

The first sign of moisture in a dial thermometer usually shows up as condensation inside the dial glass. You are probably familiar with this dial fogging problem which causes difficult reading and the eventual corrosion of the bimetallic element. You may not, however, be familiar with another and actually more serious moisture problem—bimetal "freeze-up."

If moisture is sealed in, or enters a thermometer dial it will find its way to the bimetal element. Then at extreme low temperatures this moisture freezes on the element and bearing surfaces, and the bimetal element will not function should the temperature go lower. Therefore, the operator of the equipment would never know that the temperature had gone below the last indication when the element became frozen.

Here's what makes such a condition hard to spot. The thermometer would operate properly again after a temperature rise of perhaps 20°, and would continue accurate indication even though the fluid dropped again to an even lower temperature than before. However, after it remained at the new low for a few hours, it would again freeze up. Then, as before, any further drop in temperature would not be indicated.

Only a dry-air hermetic seal, as used by RMC, can prevent both dial fogging and bimetal freeze-up. RMC even goes a step further by providing for recalibration at any time without breaking the air-tight seal. An external dial reset screw—exclusive with RMC—permits recalibration without opening the instrument in any way.

Write, wire or phone for general catalog. If yours is a special application, tell us your requirements—RMC engineers will work with you in solving it. Rochester Manufacturing Co., 209 Rockwood St., Rochester 10, N. Y. (Telephone: BRowning 1-2020).

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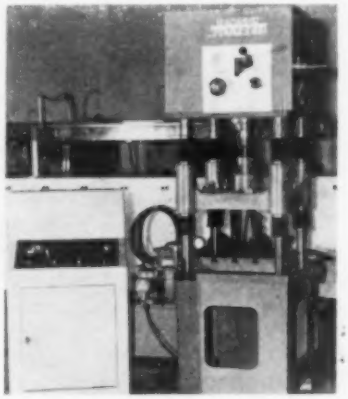
BRIEFS

stops reduces noise level while machine is operating.

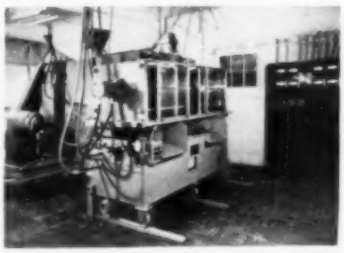
Designed for high speed, progressive stamping operations, the



press will deliver 600 strokes per minute. It occupies an area of 20" x 20" between bedposts and has a daylight area of 13". ▼▼▼

Hydraulics Operates Blow Molding Machine

Hydraulic operation of this blow-molding machine provides smooth, cushioned, mold closing that speeds production, maintains accuracy, and reduces downtime.



The new unit manufactured by Peuchen Engineering Corp., Wilmington, Del., is fully hydraulic, including the manifold valve which directs the flow of plastic to alternate heads. The actual blowing of plastic is the only operation done pneumatically. Cushioned closure is done with a two-stage hydraulic system. First, a low pressure pump closes the mold quickly to

within the last ½" of platen travel. With the platen practically stopped, the mold closes smoothly, and a high pressure pump clamps the assembly together. Jolting, jarring, and vibration characteristics of air-operated equipment are eliminated. ▼▼▼

Fluid Seal Meeting in England

The British Hydromechanics Research Association has announced an international meeting on fluid seals to be held April 17th to 19th, 1961, in Kent, England. Topics will include liquid seals for rotating and reciprocating shafts and positive and labyrinth gas seals. Papers will also be presented on sealing materials, dynamic seals, and seals for extreme conditions of speed, pressure and temperature. For further information contact Mr. H. Stephens, B.H.R.A., South Road, Harlow, Essex, England. ▼▼▼

New Books

Proceedings of the 1960 Heat Transfer and Fluid Mechanics Institute, *edited by D. M. Mason, W. C. Reynolds, and W. G. Vincenti,* 259 *pp,* $8.75, *Stanford University Press.*

This book has reports of 18 completed investigations in fundamental research. The reports were presented at the institute's meeting at Stanford this summer. Papers were selected to interest those of a wide group of scientific and engineering disciplines. Topics are Vortex Motion, Boundary Layer Flows, Origins of Turbulence, Flows not in Thermodynamic Equilibrium, Separated Flows, Two-Phase Systems, and Thermal Radiation Problems in Space Technology. Authors are from university, government, and industrial research laboratories.

A typical paper contains a statement of the problem, an explanation of the approach, formulation of the problem, results and discussion, and conclusion. Charts, graphs, and photos clarify the text. The text relates its topic to other work in the field. ▼▼▼

The photograph below shows RMC Pressure Gauges undergoing severe vibration testing on big Calidyne High Frequency Vibration Test System. These gauges undergo accelerated tests from 0-2000 CPS—up to 25 G intensity and up to 350° F.

RMC *direct-drive* Pressure Gauge eliminates vibration problems

The RMC *direct-drive* Pressure Gauge is rugged and resilient. It is the first direct-drive helical bourdon gauge—inlet pressure acts directly on a helical bourdon to drive the pointer. The helical coil, as a simple spring, is resilient and fully balanced, and is not affected by shock or vibration.

With its direct drive, there are no gears or linkage to gyrate and score on vibration—no unbalanced bourdon "C" springs and hair springs to whip. Direct-drive action means a stable pointer—no loss of power, too. Pointer action of the RMC gauge is steady, positive and alive—no need to tap the gauge to read. Soft hair springs and backlash springs are not used.

Shown at far right is the pointer-coil unit used in 3" and 5" concentric models. The pointer in these models is attached directly to the end of the pressure element. At the near right is a cutaway view of the compact 1½" and 2" eccentric models. The pointer in these models is actuated directly by a simple pivot. Both types offer the same direct-drive, helical bourdon advantages. Pressure ranges from 0-1000 to 0-10,000 psi.

Write, wire or phone for general catalog. If yours is a special application, tell us your requirements—RMC engineers will work with you in solving it. Rochester Manufacturing Co., 209 Rockwood St., Rochester 10, N. Y. (Telephone: BRowning 1-2020).

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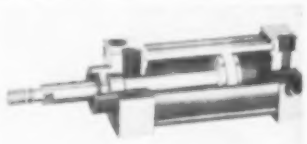
NEW PRODUCTS

Components, tools and equipment for fluid power systems. For more information fill in and mail post card bound in this issue.

1-INCH BORE AIR CYLINDERS

For high-speed assembly machines. Teflon rod seal-wiper combinations and piston seals. Seal-wiper and



barrel seals can be removed without disassembling cylinder. Shoulders on barrel ends support barrel seals radially. O-ring expansions hold piston seals against cylinder. Rods are hard chrome plated. Steel end caps. Steel barrels have black oxide finish. Mountings are front or rear flange, trunnion, foot, and clevis.

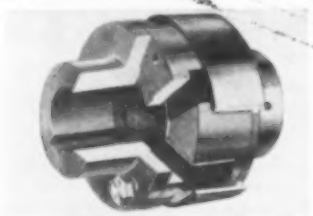
Specifications: Eight standard strokes from ½" to 5". For 200 psi.

Designation: Series B—*Hydro-Line Mfg. Co., Rockford, Ill.*

Circle **300** on Reader-Service Card

FLEXIBLE COUPLINGS

One set of jaws in removable ring form. This permits independent rotation or radial removal of connected machinery. Individual, free-floating load cushions are of material suited to the application. Full load is transmitted through cushion compression only. No wear on metal jaws. Lubrication is unnecessary. Pulling removable jaw ring



outwards provides enough clearance for independent rotation of either end of coupling. By reversing a set of cap screws from one body to the other, connected machinery can be removed radially without disturbing coupling's power-transmitting elements.

Specifications: Standard CO couplings have maximum bores from 1⅜" to 5½". They range from 2.58 to 56 hp at 100 rpm. Heavy-duty HQ maximum bores range from 1⅜" to 8½". They are for 7.77 to 810 hp at 100 rpm.—*Lovejoy Flexible Coupling Co., Chicago.*

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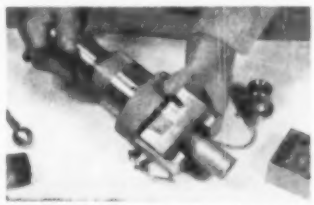
BALLISTIC FLARER

Forms tubing by explosion. Provides SAE hydraulic 37-deg flare. Can flare heavy-wall stainless steel tubing. To operate, slip fitting nut and sleeve over tube. Place tube in



tool against stop, and clamp. Insert cartridge. Screw on breechblock. Tap firing pin. Pressure increases clamping force on tubing. Then firing cone plunges about an inch, forming and coining flare. Tube bends can start two inches from end to be flared.

Specifications: Kit includes flaring dies for ¼", ⅜", ½", 1" and 1¼"-OD tubing.—*Parker Fittings & Hose Div., Parker-Hannifin Corp., Cleveland.*

Circle **302** on Reader-Service Card

QUICK-CONNECT COUPLING FOR PERMANENT PIPING

Requires no flexible hose. Seals tight on user's choice of rubber gasket. Used in pairs for addition or removal of relief, flow-control, or check valves, gages, pumps, or meters. In cadmium-plated steel, anodized aluminum, or 316 stainless steel, passivated.

Specifications: End fittings for 1"-ID size are 3/4" and 1" male and female pipe thread, and 3/4", 13/16", 7/8", 15/16", 1", 1-1/8", 1-13/16", or 1-1/4" tube or brazing or welding. End fittings for

1/2"-ID size are 3/8" male and female pipe thread, 1/2" male pipe thread, and 11/16", 5/8", 1/2", 7/16", 3/8", or 5/16" tube for brazing or welding.

Designation: Rigid-Line Series—*Snap-Tite, Inc., Union City, Pa.*

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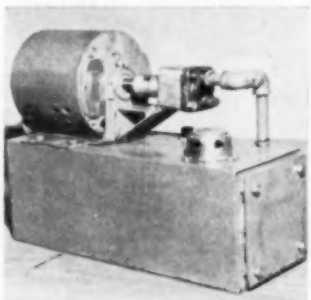
HYDRAULIC POWER UNIT

Compact unit maintains low fluid temperatures. Can be supplied with accumulators, pressure switches, and unloading valves to specific requirements.



Specifications: Flow rates to 3.4 gpm at 2000 psi. For pressures to 2500 psi.—*J. E. Myles, Inc., Detroit.*

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Continued on page 52

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57-306

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SYRACUSE 3, N. Y.
Ralph W. Earl Co.
GRanite 5-5145

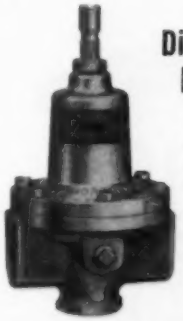
TULSA, OKLA.
Nix Supply Co.
DIamond 3-8916

VANCOUVER, B. C.
Galbraith & Sulley, Ltd.
CHerry 5121

LACHINE-MONTREAL, QUE.
Cowper Co., Ltd.
MElrose 7-6746

TORONTO, ONT.
John Spotton Co., Ltd.
CLifford 9-8276

Norgren Diaphragm-Type Relief Valves and Flow-Control Valves



Diaphragm-Type Relief Valve

Type 62AX— for use with air, water, oil and similar fluids. ⅛", ¼", ⅜", ½", ¾", 1" pipe sizes. For relief pressures up to 250 psig (¼", ⅜", ½") and up to 125 psig (¾", 1").

Compact Diaphragm-Type Relief Valve

Type 40AB— for use with air, water, oil and similar fluids. ⅛", ¼" pipe sizes. Relief pressure adjustable up to 100 psig.

Pop Safety Valves

Type 1000— for air. ⅛", ¼", ⅜", ½" pipe sizes. Relief pressure ranges: 25 to 200 psig.

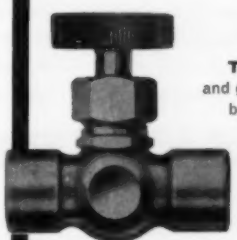
Flow Control Valves

Types 1100 and 1200— for air, oil, hot and cold water, steam, non-corrosive gases and liquids. Two-way and single-way valves. ¼", ⅜", ½" pipe sizes. Max. pressure: 250 psig on air and hydraulic systems, 125 psig on saturated steam and hot water systems.

Low Flow Relief Valves

Type 61A— for air, water and non-corrosive gases. ⅛", ¼" pipe sizes. For relief pressures: 25 to 300 psig.

Needle Valves



Type N— for air, liquids and gases that do not affect brass. ⅛", ¼" pipe sizes. Maximum pressure: 250 psig.

For complete information on these products or the complete Norgren line of compressed air filters, pressure regulators and lubricators, call your nearby Norgren representative, listed at left—or write for descriptive literature.

C. A. NORGREN CO.

FOUNDED IN 1926

3402 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

Circle **94** on Reader-Service Card

jamesbury

"Double-Seal" Ball Valves

STYLE "H" SERIES HIGH PRESSURE

3000 TO 4500 P. S. I.

"Double-Seal"™ BALL VALVES

- **Pressure range: high vacuum to high pressure**
- **Virtually leakproof and indestructible in service**
- **Temperature range:—320°F to +400°F***
- **Eight sizes ¼" through 2"—available in both pipe and tubing threads**
- **On-Off service, quarter-time, full flow construction**

UNIT BODY CONSTRUCTION

. . . a unique, compact, single-piece body of rugged design which permits wide high-pressure, high-vacuum applications, especially recommended for hydraulic equipment and the handling of compressed gases or hazardous fluids. Cryogenic (low temperature) uses are also feasible with extended bonnet adaptation. Available in Straight Tubing or Standard Pipe Thread as catalog items. Flanged valves available on special order.

HIGH PRESSURE PERFORMANCE DATA

¼ In. — ½ In.	¾ In. — 2 In.
4500 PSI (—20°F to +160°F)	3000 PSI (—20°F to +160°F)

VALVE MATERIALS

Jamesbury Style "H" Double-Seal Ball Valves are available in Carbon Steel, 303 and 316 Stainless Steel.

"TEFLON", Special Nylon or synthetic rubber seats and seals.

**Selection of valve seats and seals determine the temperature and pressure ratings.*

Write for Materials and Pressure Specification Sheets for Style "H" series for performance data.

* Patented

JAMESBURY CORP., 72 NEW STREET, WORCESTER, MASS.

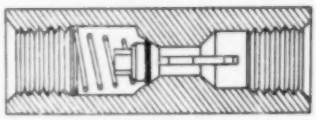
Distributors in Principal Cities

Circle **74** on Reader-Service Card

NEW PRODUCTS

CHECK VALVES

Allow free flow in one direction. Block reverse flow. One-piece bodies. Soft seats. Large flow passages. In-line construction. Horizontal poppet guide. Self-cleaning.



Stainless steel spring. Single seal. Positive poppet stop keeps spring from over-compressing.

Specifications: For pressures to 5000 psi. In brass, steel or stainless steel bodies with ⅜" to 1" dry seal threads or AND-10050 ports with straight threads.—*Manatrol Corp., Cleveland.*

Circle **305** on Reader-Service Card

FLOWMETER

Instantly reports rate of flow in gpm. No switches. No adjustments to make. Requires no timing. For quick connection to oil line.

Specifications: Unit is about the size of a cigar box. For pressures to 1500 psi. For any viscosity oil.—*Perma-Weld Co., Inc., Topeka.*

Circle **306** on Reader-Service Card

AIR REGULATOR

Regulated pressure provides pilot energy. Regulated pressure pushes up against loading diaphragm. Relief valve allows air to pass through radial opening between pilot diaphragm and loading diaphragm. Downstream regulated pressure moves into control chamber, and surrounds stainless steel measuring capsule. Some air flows through

Continued on page 54

Webster hydraulics "muscle" a boardinghouse reach . . .

It stretches way out for a hearty bite, digs deep and unloads high over a truck side. Hydraulics give this versatile backhoe its sure-footed stance, swivel-hipped performance, accurate bucket and boom control. In many of these mobile rigs, a Webster JD hydraulic pump powers the action — in up to seven separate cylinders!

Not an unusual assignment — for the JD series has an uncanny ability to handle demanding jobs with speed, sureness and exceptional dependability. That's why you find them on a wide range of industrial, agricultural and construction machines . . . in pressure lubricating, oil circulating and lift systems.

Webster JD positive displacement, gear-type pumps are available in 5 sizes — from 5 to 23 gpm — with pressures to 2000 psi, speeds to 2400 rpm. Drive is direct, gear or belt. Side porting standard, end optional. Compact design fits into tight corners.

Need help in a specific hydraulic application? A specially trained Webster hydraulics engineer is ready to assist you. Write for action!

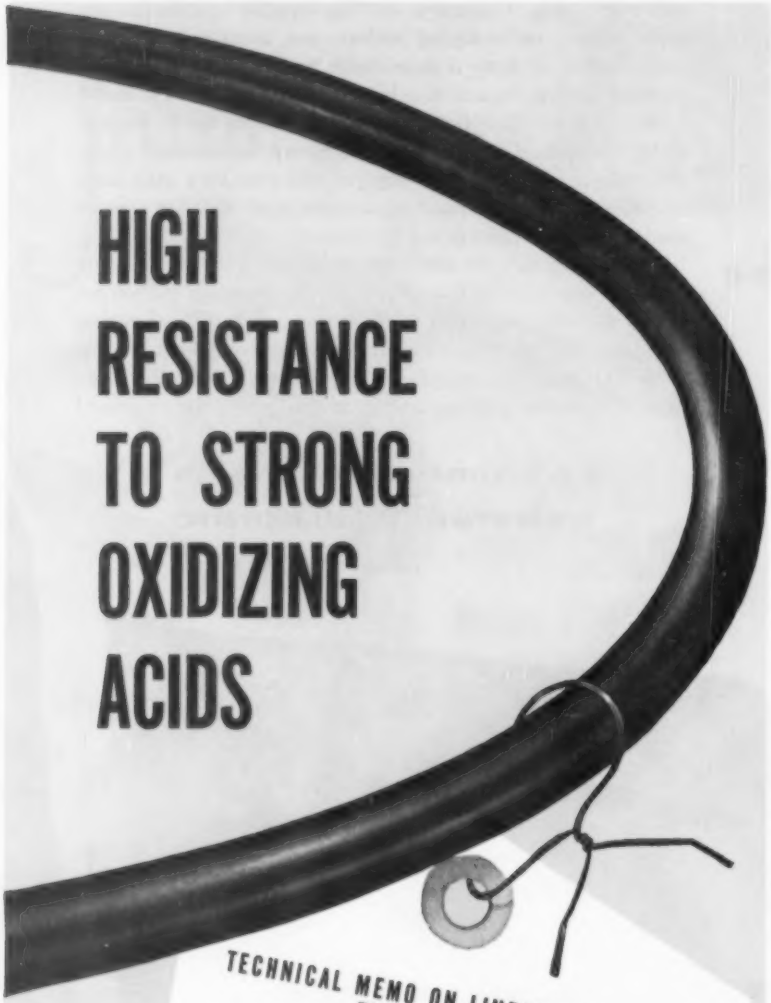
JD SERIES POSITIVE DISPLACEMENT GEAR-TYPE PUMP — Send for complete engineering characteristics, performance and installation data.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

Circle **140** on Reader-Service Card



TECHNICAL MEMO ON LINEAR COMPOUNDS 7661-70 and 7662-70

. . . outstanding material for O-Rings

- 7661-70 has good resistance to red fuming nitric and other strong oxidizing acids.
- 7662-70 has low compression set properties.
- Both compounds highly resistant to most petroleum fuels and oils.
- Effective sealing from −20°F to +300°F.

MATERIALS COMPATIBLE WITH THESE COMPOUNDS

Acetylene Tetrabromide • Air • Aliphatic Solvents • Amyl Alcohol • Arochlor 1242 • Arochlor 1248 • ASTM No. 1 Oil • ASTM No. 3 Oil • Cellulube 1000 • Crude Oil • Ethyl Alcohol • Greases • Hydrochloric Acid • Isobutyl Alcohol • Iso-octane • JP-3 Fuel • JP-4 Fuel • JP-5 Fuel • MIL-F-25558A • MIL-L-2105 • MIL-L-9000 • MIL-L-15016 • MIL-L-15017 • MIL-L-17331 • MIL-O-5606 • MLO-8200 • Motor Oil • Nitric Acid • Propyl Alcohol • Pydraul A-200 • Pydraul F-9 • Shell Iris 902 • Shell Tellus • Sulfuric Acid • Tall Oil • Titanium Tetrachloride • Transformer Oil

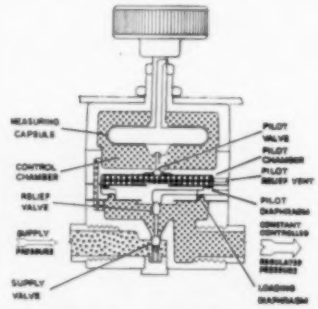
For complete technical data—including list of incompatible fluids—request Bulletin 56709-1. Linear, Inc., State Road and Levick St., Philadelphia 35, Pa.

PERFECTION IN RUBBER
LINEAR
LINEAR, Inc. STATE ROAD & LEVICK ST. PHILA. 35, PA.

Circle **81** on Reader-Service Card

NEW PRODUCTS

pilot valve, into pilot-pressure chamber, and out through pilot-relief vent to atmosphere. Minute movements of measuring capsule substantially change control pressure in pilot chamber. This change



reacts directly on pilot diaphragm and causes movement of supply or relief valve, to offset slight errors in downstream pressure. Since pilot pressure is bled directly to atmosphere, there is no exhaust valve pick-up or initial drop-off.

Specifications: Holds pressure to 0.02% of its range over substantial variations in supply pressure, flow, and ambient temperature. In 2-25, 3-60, and 3-120-psi ranges. For ⅛", ¼", or ⅜" NPT pipe.—*Lexington Controls, Inc., Burlington, Mass.*

Circle **307** on Reader-Service Card

DYNAMIC LOAD SIMULATOR CONTROL

Applies programmed load or stroke to items which have force vs. displacement or force vs. velocity

characteristics which require test. Provides load signals for any Pegasus single-stage servovalve and excites and accepts feedback signals from any Pegasus actuator which has potentiometer instrumentation. Provides excitation and de-

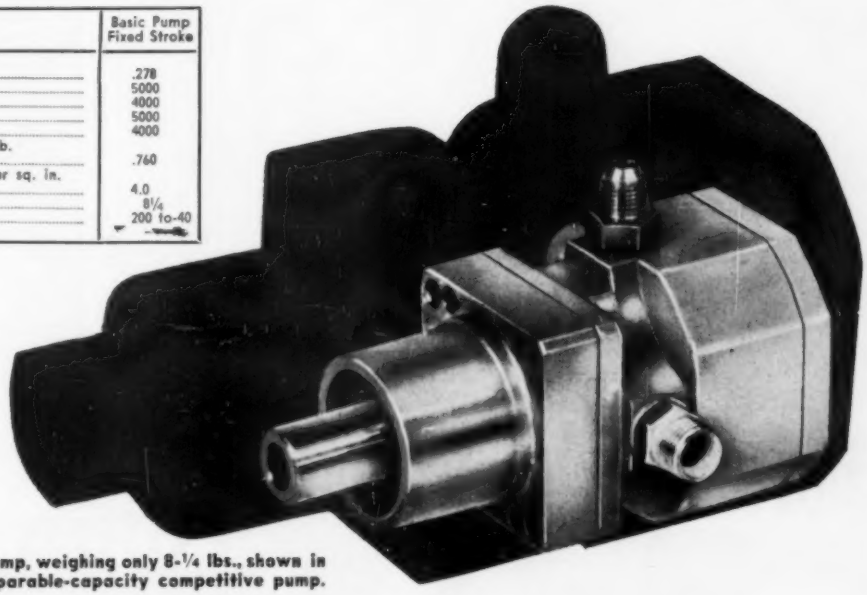
Continued on page 56

new LUCAS-ROTAX *industrial*

HYDRAULIC PUMPS AND MOTORS

offer the most advanced compact design

PUMP DETAIL	Basic Pump Fixed Stroke
Fluid displacement (cub. ins./rev.)	.278
Nominal working pressure (peak) (lb. per sq. in.) (continuous)	5000 4000
Nominal speed (peak) (r.p.m.) (continuous)	5000 4000
Input h.p. at 1,000 r.p.m. and 1,000 lb. per sq. in. differential	.760
Max. Torque (lb./ft.) per 1,000 lb. per sq. in. fluid pressure differential	4.0
Weight (lb.) Basic Pump	8¼
Operating temperature, ° F	200 to-40



LUCAS-ROTAX 1A4 pump, weighing only 8-¼ lbs., shown in comparison with comparable-capacity competitive pump.

If you are interested in industrial hydraulic pumps or motors in the 1.5 to 108 g.p.m. range at pressures to 5000 p.s.i., you'll find more good design features in Lucas-Rotax pumps and motors than in any other quality line.

Lucas-Rotax industrial hydraulic pumps and motors are smaller and lighter than conventional units with low noise level in spite of high operating speeds. They offer fast response rate in pressure compensation and the low and medium capacity units can be operated from 2-pole motors to reduce the cost of the prime mover.

Pumps are available as variable volume, variable volume pressure compensated, overcentre cam (reversible) or fixed volume. Motors can be supplied in variable or fixed volume. Both pumps and motors deliver high performance with minimum maintenance. Available in quantity from domestic stock—call or write for technical data.

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NEW PRODUCTS

tection for most four-arm strain gages. Position or load can be controlled. Position and load can be read. Function generator provides cyclic program. Function generator develops sinusoidal or sawtooth wave-form. External programming can be introduced. System shuts down if load or stroke exceeds adjustable rate.

Specifications: 24" x 24" x 60" cabinet contains all control equipment.

Designation: Model 550—*Pegasus Laboratories, Inc., Berkley, Mich.*

Circle **308** on Reader-Service Card

LEAK-DETECTING TAPE

Flexible. Adhesive-backed. has indicators which change color when exposed to the gas or liquid for which it is made. Types include those for detection of anhydrous ammonia, chlorine, hydrogen, hydraulic fluids per MIL-H-5606, and acid fumes. In wrap-around style for leakage from system connections. In surface-mounting style for random gas leakage.

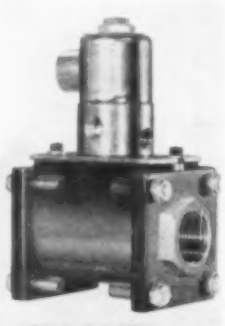
Specifications: Can detect as little at 1/100 cc per hour.

Designation: Tec-Tape—*Pyrodyne, Inc., Los Angeles.*

Circle **309** on Reader-Service Card

VALVE

Squeezing action controls flow of air, oil, chemicals, and grinding slurries. No poppets or spools, metal-to-metal contacts, or metal-to-rubber seals. With valve open,



supply pressure through inlet port forces elastic rubber sleeves against tube. Fluid flows around inlet plug, through outlet port. To close valve, pilot pressure is applied between tube ID and sleeve's outer periphery. Sleeve collapses over rounded ends of inlet and outlet end plugs, sealing off supply pressure. Only action is flexing of sleeve.

Specifications: For 200 psi. Pipe sizes are ¼" to 2".

Designation: Tube-O-Matic—*Airmatic Valve, Inc., Cleveland.*

Circle **310** on Reader-Service Card

TEFLON V-SEALS

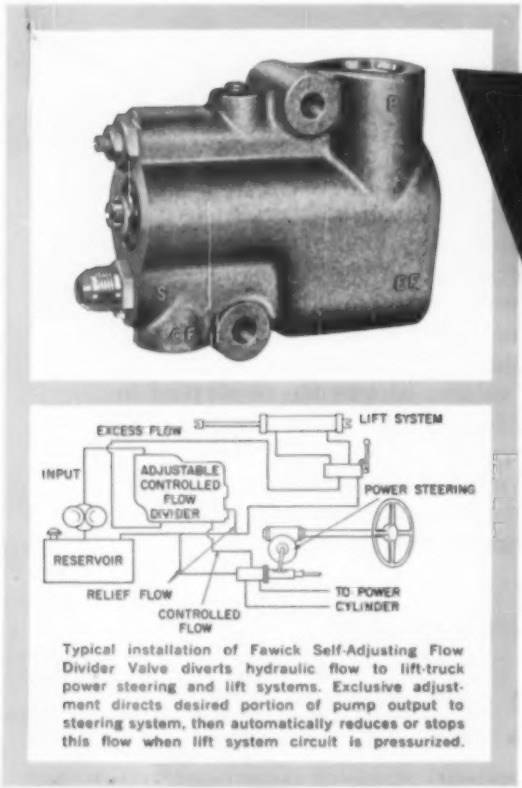
Have Teflon's excellent chemical and mechanical properties, and greater resiliency and toughness. Molded under ambient temperatures about those under which they perform.

Specifications: Maintain dimensional accuracy at 0 to 1000 psi. −350 to 500 F.

Designation: Fluorlastic—*Joclin Mfg. Co., Wallingford, Conn.*

Circle **311** on Reader-Service Card

For more NEW PRODUCT reviews turn to page 128



Typical installation of Fawick Self-Adjusting Flow Divider Valve diverts hydraulic flow to lift-truck power steering and lift systems. Exclusive adjustment directs desired portion of pump output to steering system, then automatically reduces or stops this flow when lift system circuit is pressurized.

control fluid flow better

with . . .

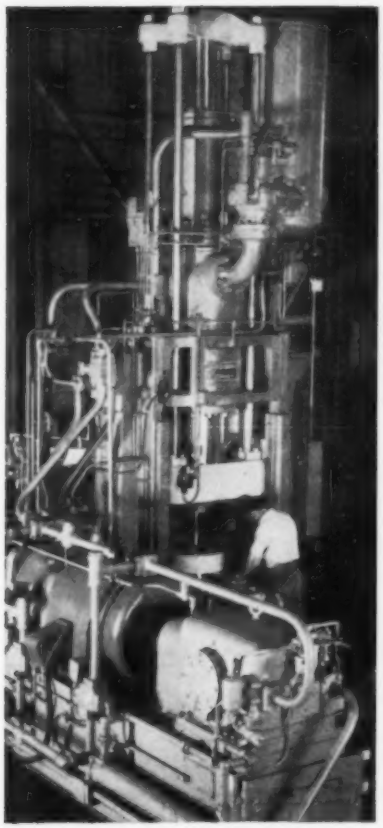
FAWICK FLOW DIVIDER VALVES

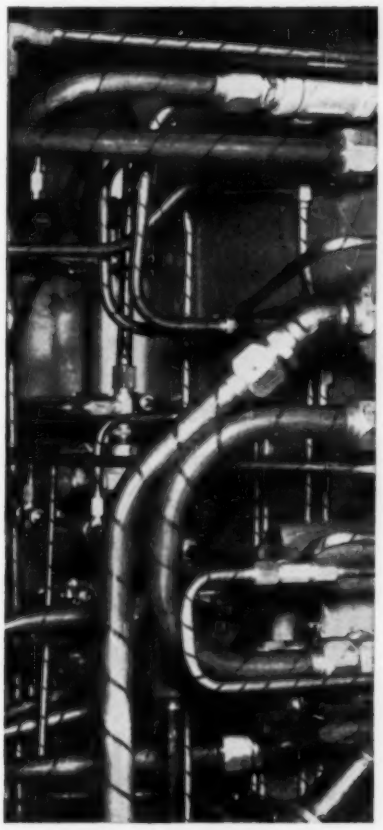
- rated capacities from 15 to 80 gpm
- directs pump output to either of two hydraulic circuits, or to both circuits simultaneously
- models available for fixed flow rate or adjustable for infinite variation of flow rate proportions
- easy installation, maintenance
- quiet, smooth, chatter-free operation
- reliable with standard hydraulic fluids at temperatures to 250° F.
- full operation even on low circulation pressure
- available with built-in relief valve

For more information, write for technical bulletin on Fawick Flow Divider Valve.

FAWICK
HYDRAULIC-ELECTRONIC DIVISION

9919 CLINTON ROAD • CLEVELAND 11, OHIO • ATLANTIC 1-2211





FOR HIGH PERFORMANCE... SPECIFY ELECTRUNITE HYDRAULIC FLUID LINE TUBING—SPECIAL SMOOTH I.D. CYLINDER TUBING

Tube users with critical tubing requirements specify Republic ELECTRUNITE. Because, the consistent uniformity of concentricity of ELECTRUNITE welded steel tubing makes this tubing better able to withstand stubborn resistance to fatigue.

The uniform concentricity of ELECTRUNITE Hydraulic Fluid Line Tubing, produced to meet all test requirements of the JIC Standards, coupled with uniform heat treatment, insures uniform flaring characteristics, uniform ductility, easy bending. Big savings in original and in replacement installations.

And, you can recognize ELECTRUNITE by the blue spiral marking stenciled end-to-end on every length.

ELECTRUNITE Special Smooth I. D. Hydraulic Cylinder Tubing, in sizes from 1" through 4½", and up to .187 wall thickness, reduces costly, time-consuming machining because uniformity is built-in. Uniform wall thickness, strength, diameter, ductility assures predictable, dependable, physical characteristics with every order.

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Here's data on the ideal pump for power hydraulic applications

Announcing NEW DE LAVAL IMO Pump Bulletin

New Bulletin 3200 contains all the data you need on De Laval IMO constant-displacement, rotary, screw type pumps. In its pages you will find (1) extensive application data including charts on fuel oil, SAE oil, and turbine oil viscosities; (2) selection information, including specific examples; (3) complete performance data on each IMO model as well as (4) dimension drawings and tables. Write today for your copy of this valuable, 40-page bulletin on the unique IMO pump.

DE LAVAL STEAM TURBINE COMPANY
906 NOTTINGHAM WAY, TRENTON 2, N. J.

DL-230C

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Aeroquip Fluid Piping Service Assists Product Design Engineers

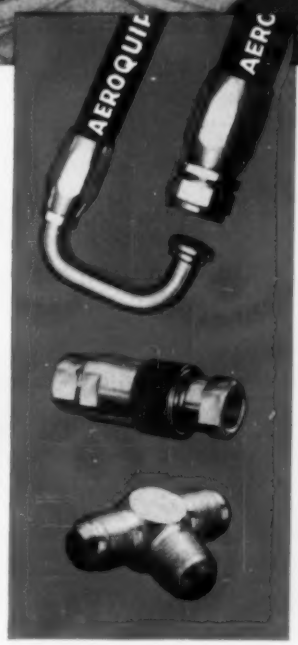
Major equipment manufacturers can use Aeroquip's Fluid Piping Service to great advantages in developing fluid systems that will provide dependable, trouble-free service in the field. Highly qualified Aeroquip Sales Engineers, for example, are on call to furnish valuable design assistance. Working right in your engineering department, these fluid piping design specialists give you the full benefits of the experience Aeroquip has gained by working with many other manufacturers.

This design assistance is only part of Aeroquip's complete service. Backed by the most complete line of fluid piping products, Aeroquip's specialists can also help you mock up and test systems, work with your production planners and expediters and assist in developing a service parts program. Aeroquip can even furnish trained field service engineers to assist in after-sales service on your equipment.

For detailed information, call your nearby sales engineer, or write to us.

- DESIGN
- PROTOTYPE
- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

Aeroquip fluid piping specialists can work with you in every phase of manufacture to assure maximum performance of fluid piping systems on your products.



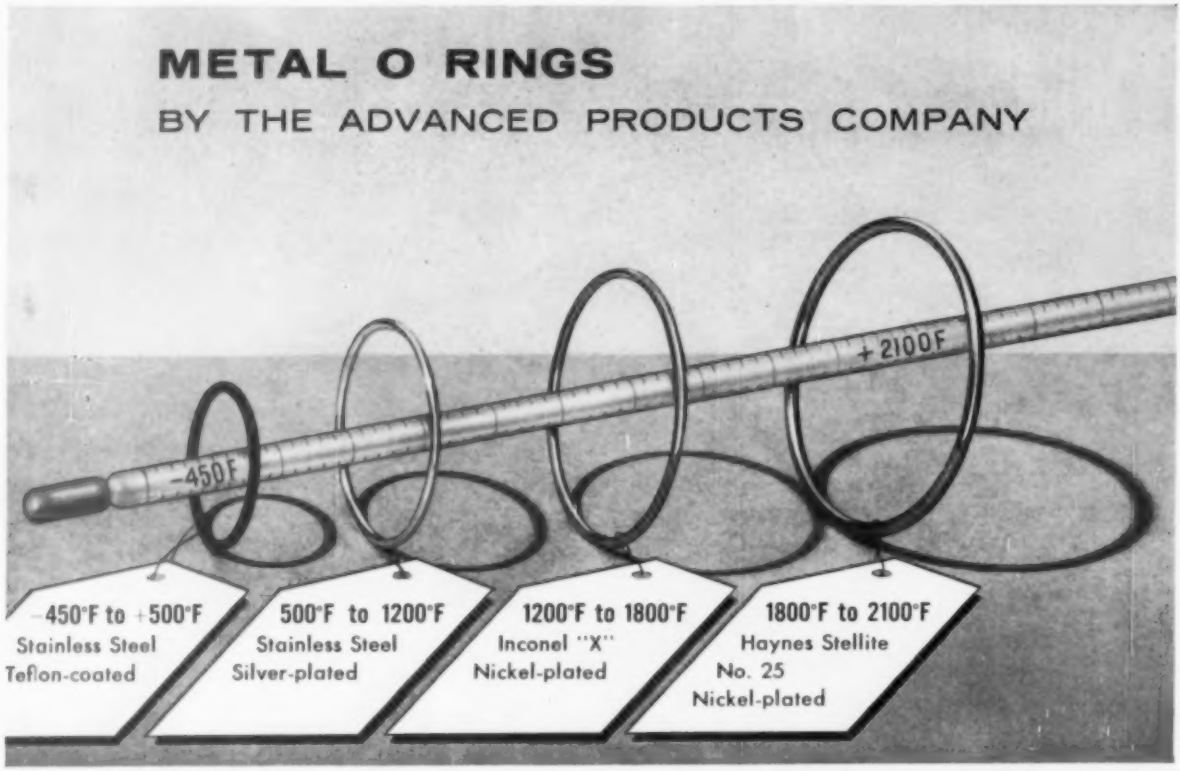
Aeroquip now produces a wide range of fluid piping products, including hose assemblies with standard or special tube configuration fittings, Self-Sealing Couplings and a new line of tube fittings.

Aeroquip

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD



Metal O Rings for any Temperature from Bearings, Inc.

Stainless, Monel, Inconel and Inconel "X" . . . electroplated or coated . . . pressure filled or vented . . . for temperatures ranging from −500°F to 1800°F.

Whether you have sealing problems caused by temperature extremes or anything else, we can help you with the proper seals.

Other Materials Available: Standard Buna-N Rubber • Viton • Teflon Silicone Rubber • Butyl Rubber • Military Spec. Series: MIL P5516A, MIL P5315A, MIL G5510A, MIL P25732, MIL R25897, AMS 7270, AMS 7271 and AMS 7274 • Teflon and Leather Back-up Washers.

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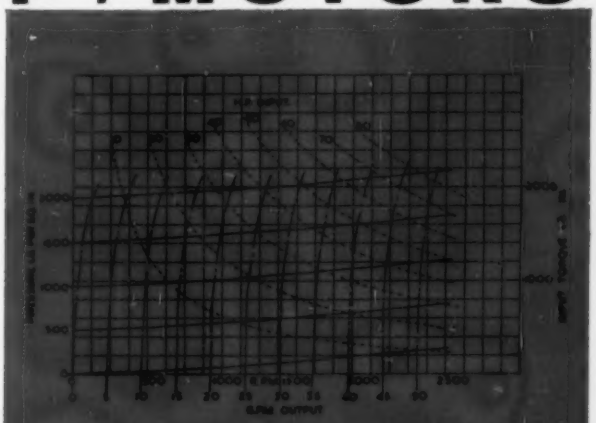
KEELAVITE
Hydraulics

GEAR PUMP / MOTORS

One of the new heavy duty gear pump/motors designed for high continuous rating.



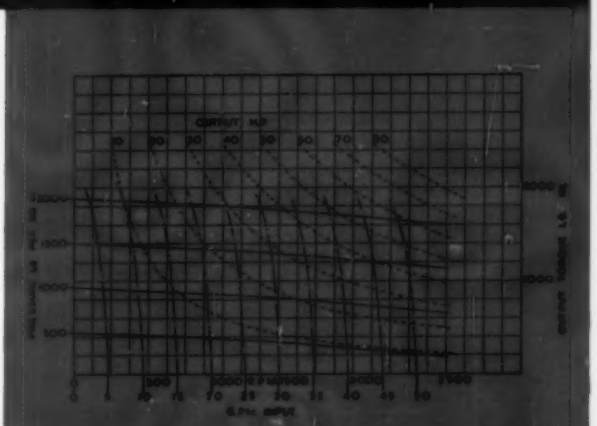
G221 GEAR PUMP

KEELAVITE GEAR PUMP/MOTORS

Within the wide range of the KEELAVITE G SERIES of GEAR PUMP/MOTORS, there is a unit suitable for any industrial use. Used as pumps, output ranges from 2.25 gpm. to 180 gpm. Motor torque ranges from 10.5 lb. ins. per 100 psi to 785 lb. ins. per 100 psi.

WHY THEY ARE BETTER

All of the KEELAVITE PUMP/MOTORS conform to a high standard of workmanship in manufacture, and are reversible without alteration in assembly. The whole range stems from six basic sizes and common components are used within each basic size. All units incorporate roller bearings.



G221 GEAR MOTOR

TYPICAL PERFORMANCE CURVES OF THE KEELAVITE G221 GEAR UNIT

THE RECOGNISED AUTHORITY ON HYDRAULIC POWER TRANSMISSION

For full details write to—

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Holland

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VALVES & FITTINGS

Valve of O-Seal System has removable flat seat and resilient nylon disc. When nylon disc is pressed against seat, there is tight shutoff. 1500 and 6000-psi series. Valve has balanced piston which extends from stem to valve bottom, below the port. 1½" and 2" valves can be easily opened or closed by hand. Valves can be installed or removed without springing line. O-ring in grooved face acts as a seal, not as a gasket. Catalog 60 also covers valve cartridge inserts, valve spacers, check and relief valves.—*Combination Pump Valve Co., Philadelphia.*

Circle **400** on Reader-Service Card

SERVO AMPLIFIER

Differential dc amplifier drives torque motors. Built-in high-voltage power supply furnishes regulated filament voltage and regulated plate voltage to amplifier. This minimizes short-term and long-term drift. Front-panel controls are gain, dither, balance, and level. Front panel has pairs of current-measuring test points. Separate input and output connectors. Amplifier can be used single-ended or push-pull at input or output. Catalog 1-652 has specifications and block diagram.—*American Measurement & Control, Inc., Waltham, Mass.*

Circle **401** on Reader-Service Card

HIGH-TORQUE FLUID MOTORS

Provide high torque at low speeds. Outer ring of gerotor is a stationary part of motor housing. It has internal teeth. They mesh with corresponding teeth on a smaller gear. Smaller gear rolls inside ring, turning about an eccentric axis in an orbit. Rotor gear rolls through six complete orbits during each rotation of output shaft. For speeds from 10 to 600 rpm, torque to 2000 in-lb, and pressures to 2000 psi. Fully reversible. Instantaneous starting and stopping. MFB-1H Series.—*Char-Lynn Co., Minneapolis.*

Circle **402** on Reader-Service Card

CYLINDER FORCE CALCULATION CHART

Matches cylinder sizes to work functions. Has chart of effective

areas. Nomogram of force, effective area, cylinder bore, and pressure. Plastic straightedge is permanently attached to varnished board. Measures 15" x 11".—*Sheffer Corp., Cincinnati.*

Circle **403** on Reader-Service Card

EDGE TYPE FILTERS

All-metal filter cartridge has discs and spacers, stacked alternately on rotatable shaft. Thickness of spacers determines degree of filtration. Cleaning blades of Auto-Klean filter are on stationary rod next to cartridge stack. When cartridge is rotated, blades comb out filter slots to their full depth. No cartridge replacement. Catalog 51-100 has cutaway drawing, description, photo of each type of filter, specifications, drawings, filter selection chart, and flow tables.—*Cuno Engineering Corp., Meriden, Conn.*

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HYDRAULIC COMPONENTS

For industrial, marine, and ordnance fields. Catalog 5001C includes data on new products. Covers power units, servovalves and systems, vane pumps, piston pumps, pressure controls, flow controls, directional controls, control assemblies, hydraulic motors, variable-speed drives, hydraulic cylinders, and accessories. A section describes each line. Has photos, drawings, tables, curves, and circuit diagrams. 74 pp.—*Vickers, Inc., Div. Sperry-Rand Corp., Detroit.*

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SCREW-TYPE PUMPS

Constant-displacement, rotary pumps propel fluid axially in a constant, uniform flow. The three moving parts are power rotor and two idler rotors. Power rotor is the only driven element. Idler rotors are sealing elements. They do no work. Their threads conform to threads of power rotor and surfaces of housing cylinder. Sealed enclosures formed by meshing of rotors inside the housing enfold fluid. As rotors turn, enclosures move axially. Bulletin 3200 explains advantages, discusses rotary pump characteristics. Has tables of temperature vs. viscosity, selection guides, performance charts, drawings, cutaways, tables of dimensions, and application photos. —*De Laval Steam Turbine Co., Trenton.*

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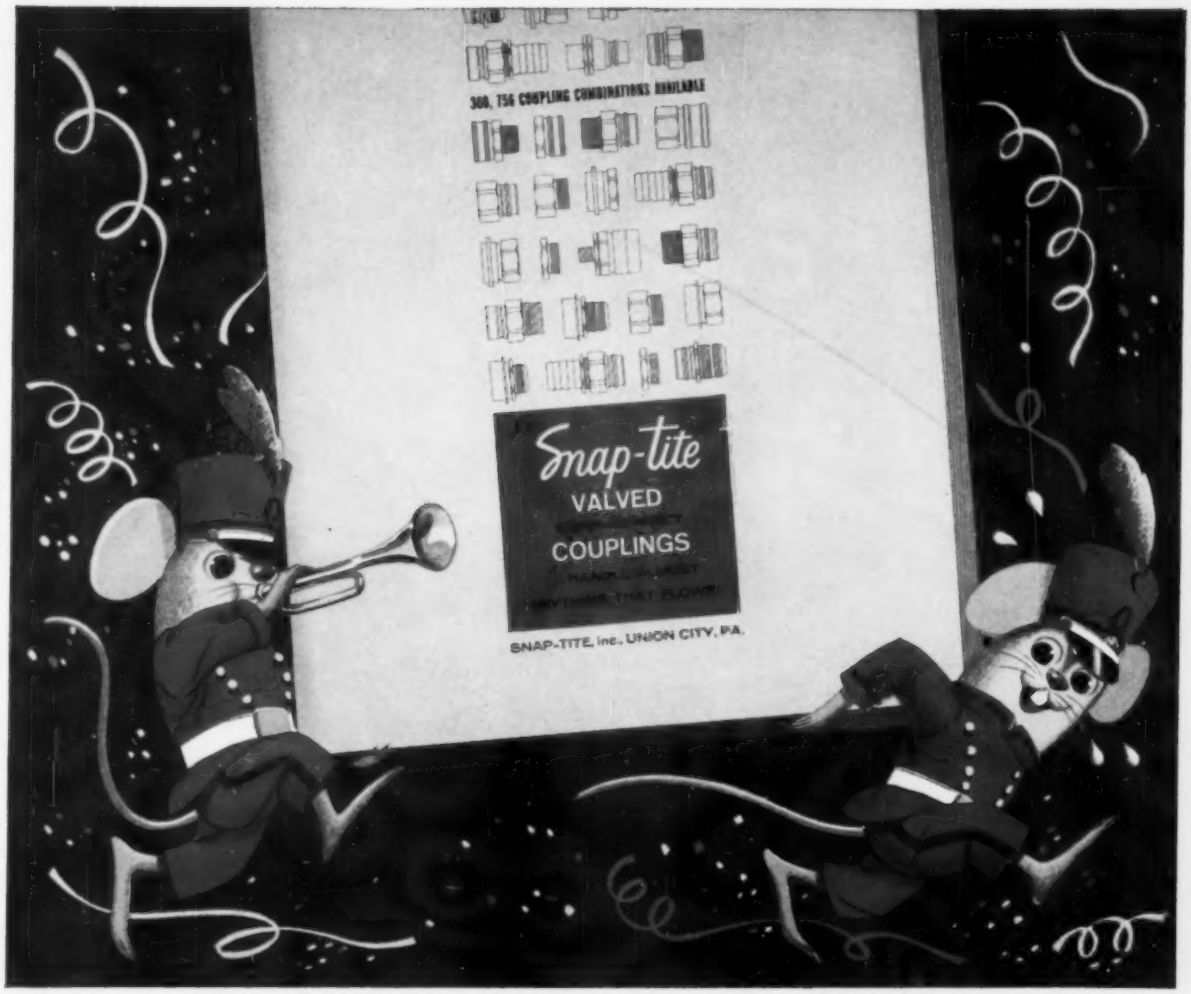
2-COLOR CODED PUSHBUTTONS

Type HO Oiltight for base or panel mounting. Type H NEMA 1 for base mounting. Type H NEMA 1 for panel mounting. Standard and assembled-to-order stations mount vertically or hori-

Continued on page 65



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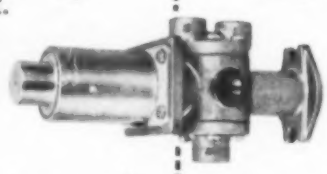

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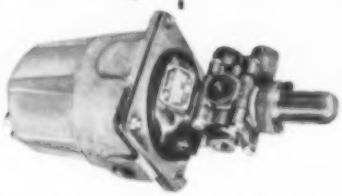

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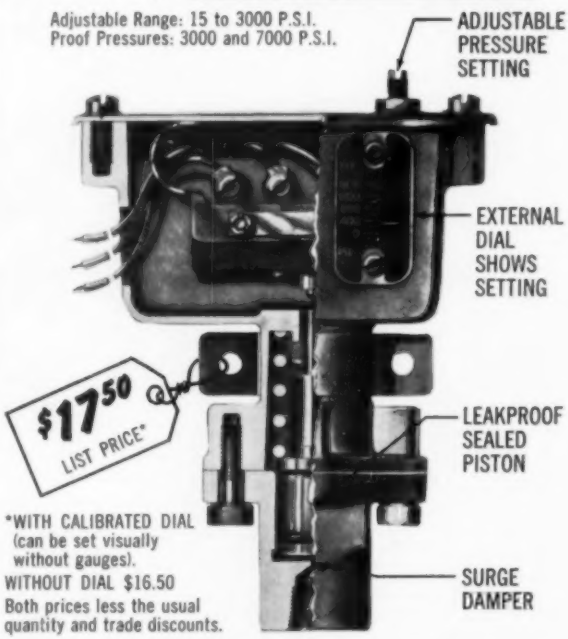

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USEFUL LITERATURE

zontally. Silver contacts have wipe action. Pub. No. PL 100-1-960 has color selection chart. It shows combinations of seven colors for coding operators, ferrules, and nameplates. Describes pushbutton units, selector switch units, standard pilot lights, and push-to-test pilot lights or lighted pushbuttons.—*Clark Controller Co., Cleveland.*

Circle **407** on Reader-Service Card

COMPONENTS CATALOG

Describes Groban-manufactured and government and industrial surplus products. Covers electrical, mechanical, and hydraulic items for OEM and maintenance. Entitled "Equipment Catalog and Hydraulic Reference Manual." 64 pp.—*Groban Supply Co., Chicago.*

Circle **408** on Reader-Service Card

MOLDED PACKINGS

Palmetto Pyramid is a V-type packing of synthetic rubbers reinforced by cotton fabric.

Asbestos reinforcement for high temperatures. Will not spiral in the stuffing box. Flared sealing lips preload packing in stuffing box. U-ring has wide lip flare and ample clearance at heel for low-friction sealing. Pisto-Rings are self-lubricating packings used on pump pistons. Bulletin MP-160 also covers Kup packings for pistons. Charts of dimensions, composition, temperature range, application. Formulas and tables for computing number of units needed. Price lists. 8 pp.—*Greene, Tweed & Co., North Wales, Pa.*

Circle **409** on Reader-Service Card

ACCUMULATORS

Capacities from 1 pint to 23 gal. Catalog has detailed drawings and complete information. Pressure-volume curve for each model. 23 pp.—*Fluid Power Div., Hale Fire Pump Co., Conshohocken, Pa.*

Circle **410** on Reader-Service Card

For more reviews of FREE LITERATURE turn to page 138

American Motors Corporation
Armstrong Cork Company
"Bendix Products Division—The Bendix Corporation"
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Boeing Airplane Company
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Radio Corporation of America
Radio Corporation of America (Whirlpool Corporation Division)
Republic Aviation Corporation
Republic Steel Corporation
Revere Copper and Brass Incorporated
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R. J. Reynolds Tobacco Company (Archer Aluminum Division)
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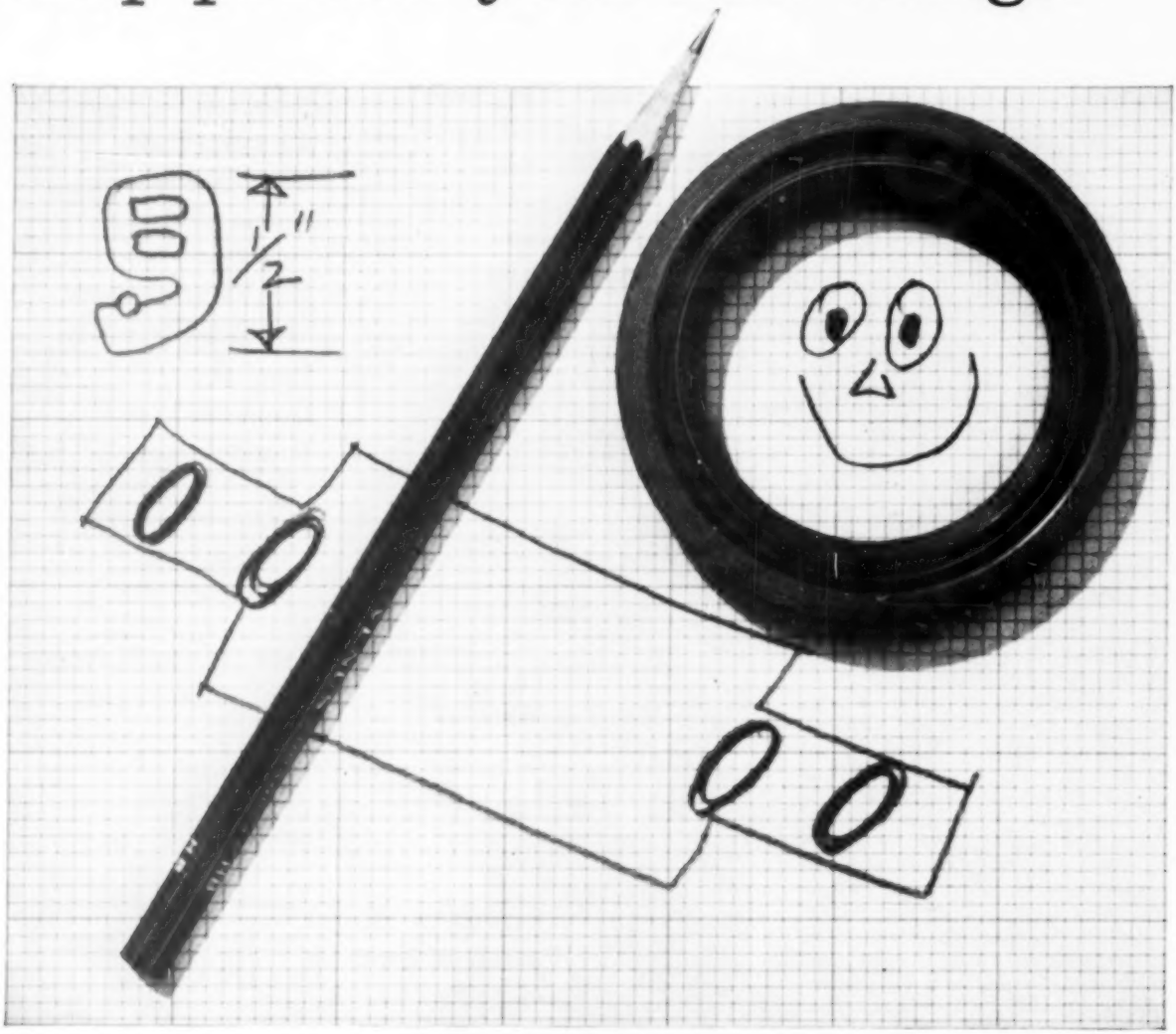
Circle **107** on Reader-Service Card

Let J-M Clipper® Oil Seals help protect your new design



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While your design is still on paper is a good time to let Johns-Manville help you determine the type of Clipper Seal that will give you most efficient machine performance. J-M has many design cross-sections to give bearings longer, better protection against heat, speed, leakage, dirt and corrosive chemicals.

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J-M Clipper Seals protect better . . . because they *are* better. Specially compounded to do each job, Clipper Seals provide maximum sealing ability, low torque, long life, easy installation and wide adaptability. For complete information, write to Johns-Manville, Box 14, New York 16, New York. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE
CLIPPER SEALS

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Melting furnace at Calumet & Hecla, Inc.—Wolverine Division, where Shell Irus Fluid 902 eliminates the danger of hydraulic line fires.

Ready... aim... NO FIRE!

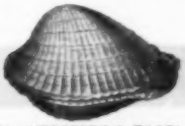
Take 10 high-temperature alloy-melting furnaces, hydraulically operated—each pouring 1500 lbs. of molten metal every hour in close proximity to "live" hydraulic lines—and you can readily see why selection of hydraulic fluids is important to Calumet & Hecla's Wolverine Tube Division.

Now the operation is made more reliable by the use of Shell Irus Fluid 902, a water-in-oil emulsion type fluid. Irus® Fluid was C & H's choice, after carefully studying other commercial hydraulic fluids—for many reasons:

1. Irus Fluid will not support combustion.
2. Irus Fluid has excellent lubricating properties.
3. Irus Fluid has hydraulic efficiency and equipment compatibility.
4. Irus Fluid is economical, costing about one-third less than other fire-resistant fluids.
5. Irus Fluid's bright yellow color makes it easy to spot and trace leaks.

In plant after plant, operators find that these advantages assure maximum safety to both personnel and equipment.

If you have a hydraulic line fire hazard, we suggest that you have the Shell Industrial Products Representative show you the many advantages in Irus Fluid 902; or write to Shell Oil Company, 50 W. 50th St., New York 20, N. Y., or 100 Bush St., San Francisco 6, Calif. In Canada: Shell Oil Company of Canada, Ltd., 505 University Ave., Toronto 2, Ontario.



AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the **Irus** ellipticus.

SHELL IRUS FLUID 902

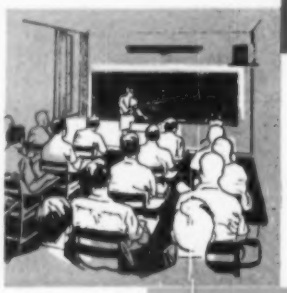
the low-cost, fire-resistant hydraulic fluid

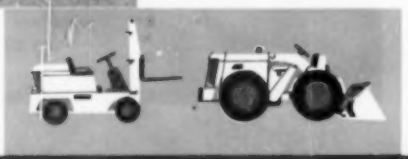
SHELL

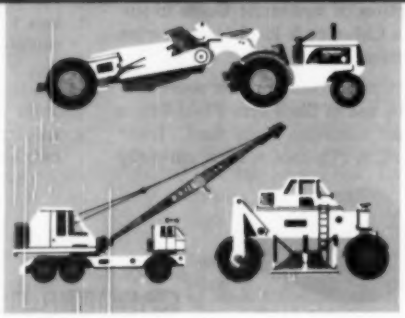
Circle **122** on Reader-Service Card

If you use hydraulics on your mobile equipment . . .

CONSIDER THE ADDED BENEFITS AVAILABLE ONLY FROM VICKERS







Unmatched research and development facilities

Developments that anticipate industry's changing hydraulics needs and the constant improvement of existing products are the twin goals of the largest and most experienced staff of technicians in the hydraulics field, working in facilities without equal. Both the facilities and the specialists are readily available to work with you on your hydraulics requirements.

Specialists to solve problems in the field

From initial designs through production, Vickers sales engineers—graduate engineers who specialize in mobile hydraulics applications – bring you a wealth of knowledge to augment your own engineering activities. Field service, too, is handled by hydraulics specialists with the know-how needed to keep equipment on the job productively.

Progressive designs based on 40 years' experience

Vickers not only pioneered mobile hydraulics but continues to lead in developing sound, new ideas. This base of hydraulics experience, without equal in the industry, assures you of dependable equipment with performance that matches your most demanding applications—at the lowest cost commensurate with top quality.

World wide parts interchangeability and service

Shipping any of your equipment to overseas markets? If you are, then you can rely on complete interchangeability of parts from any of the Vickers plants located throughout the free world. Emergency user and dealer requirements in the U. S. are supplied from regional warehouses.

For additional data on Vickers hydraulics for mobile equipment applications and the added benefits you get only from Vickers, write to address below or contact your nearby Vickers application engineer.

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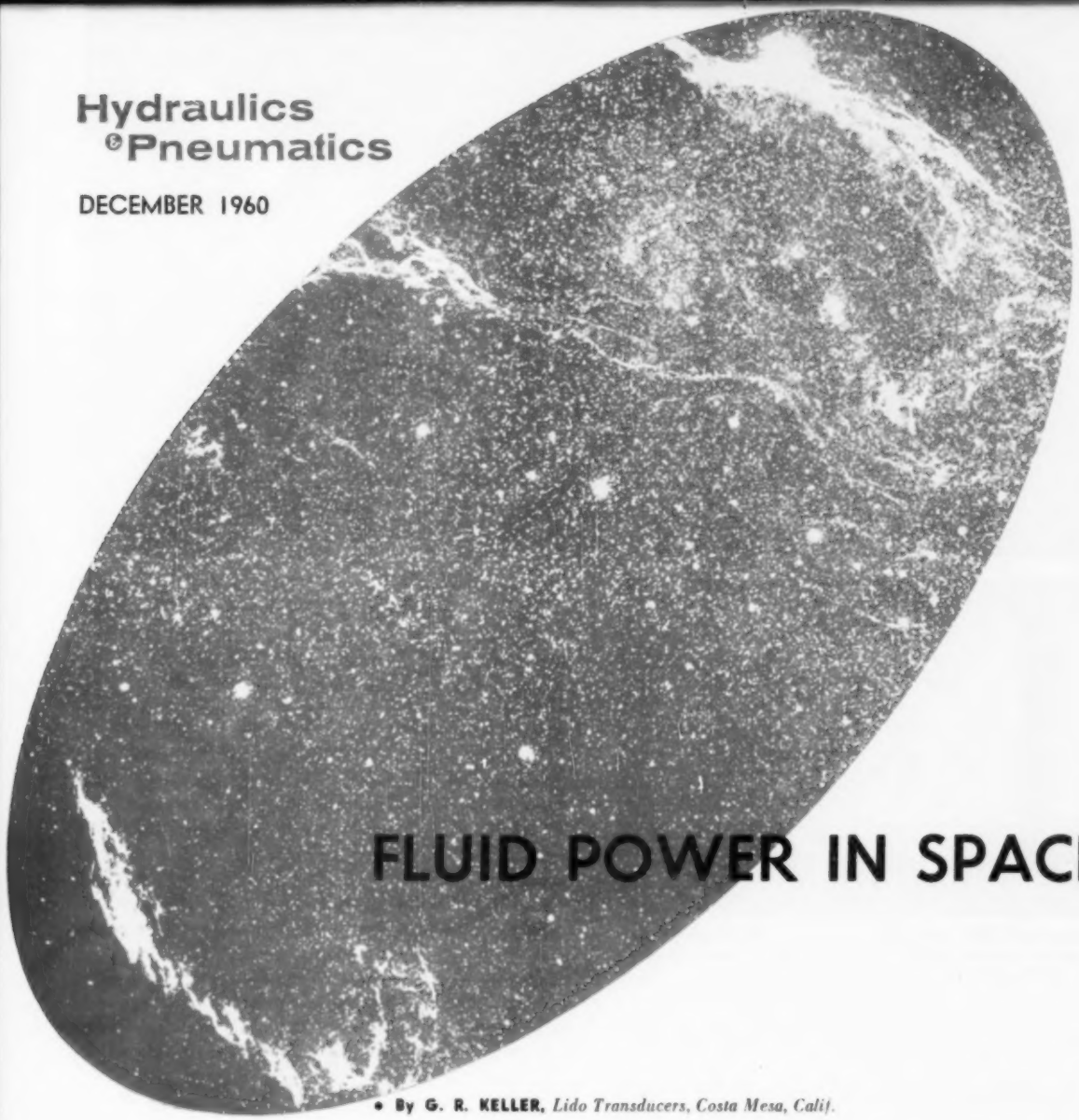
Hydraulics & Pneumatics

DECEMBER 1960



FLUID POWER IN SPACE

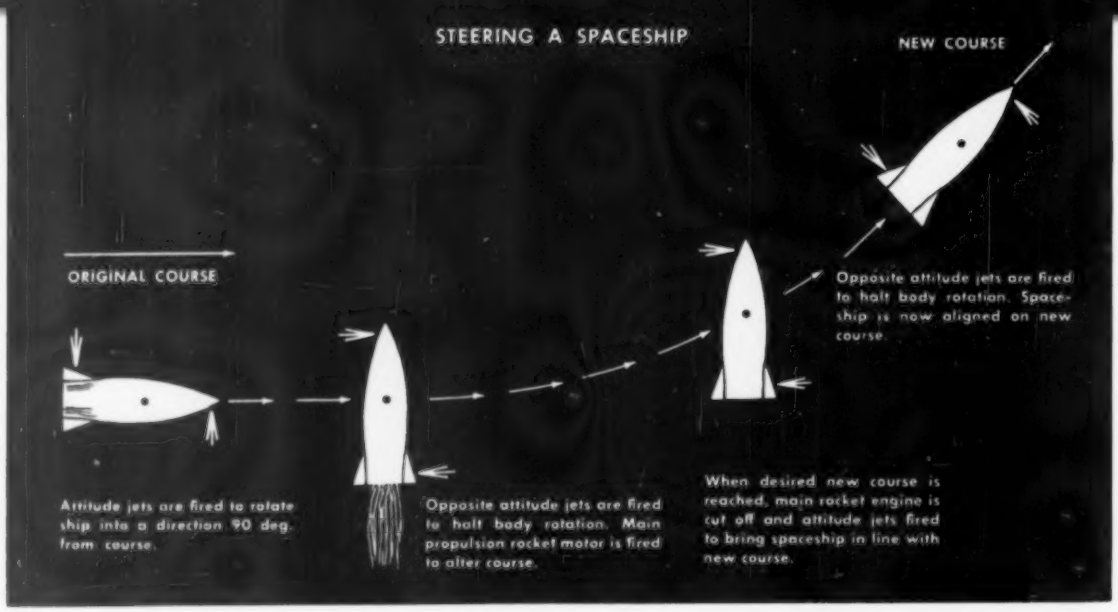
• By G. R. KELLER, *Lido Transducers, Costa Mesa, Calif.*

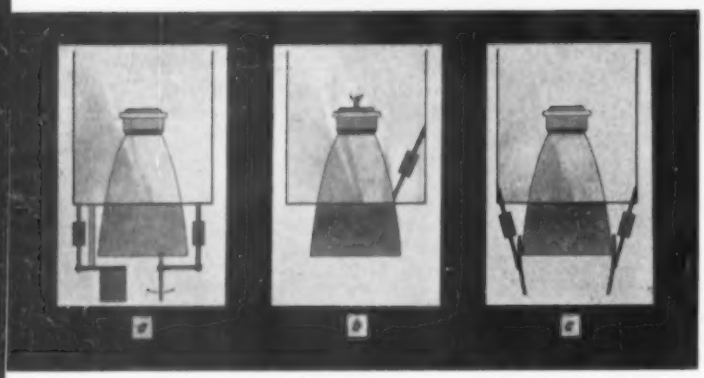
What is the role of hydraulic power in controlling space flight? The size of the space craft and its need for precise orientation will determine whether hydraulic power is reasonable for attitude control. Velocity control of any sizable vehicle might best be handled by hydraulic power.

HYDRAULIC power, which has been so successful in controlling aircraft and missiles, should be considered for the control of space craft. The consideration of hydraulic power is further justified by the need for such craft to operate in the atmosphere during boost and return. One source of control system power during both space cruise and aerodynamic flight should tend to minimize weight and control system complexity and to maximize reliability.

The tasks to be performed during a flight through space are (1) attitude control of the space vehicle, (2) control of flight direction (3) control of flight speed. These tasks are essentially the same as for normal aircraft. The distinctions lie in the degree of control re-

Network Nebula in Cygnus, courtesy of Warner and Swasey Observatory, Case Institute of Technology, Cleveland, Ohio.


STEERING A SPACESHIP
NEW COURSE
ORIGINAL COURSE
Opposite attitude jets are fired to halt body rotation. Spaceship is now aligned on new course.
Attitude jets are fired to rotate ship into a direction 90 deg. from course.
Opposite attitude jets are fired to halt body rotation. Main propulsion rocket motor is fired to alter course.
When desired new course is reached, main rocket engine is cut off and attitude jets fired to bring spaceship in line with new course.



ROCKET ENGINE CONTROL can be done by moving jet vanes in the hot exhaust streams (a), swiveling the thrust chambers (b), or rotating jetavators (c).

quired, and in the lack of air for lift, drag, and damping.

• **Methods of Control**—An airplane flying through the atmosphere actually uses attitude control to determine the direction of flight. For instance, if an airplane is to climb, the nose is rotated upward. The lift of the wings and the thrust of the engine then drive the airplane up at the desired climb angle.

Space craft cannot be controlled as easily as ordinary aircraft which depend on wing lift and engine thrust. The intense premium on weight during the boost phase will probably rule out any propulsion except when actually needed. Therefore, most of the attitude control must be performed during free fall. Whether this free fall is an orbital flight or a cruise between planets is immaterial. In either case, the free fall condition rules out any effect of the engine's thrust when controlling the vehicle attitude.

The lift used in aerodynamic flight control is also missing. Without lift and thrust, attitude changes in free fall can be made without affecting the direction or speed of flight in the slightest.

This control of attitude is, of course, extremely important. Communications and reconnaissance satellites, for instance, must be properly oriented toward earth to perform their tasks. Satellites and space platforms which will be used as astronomical observatories must be held firmly with respect to the star or planet under study. Re-entry of a space vehicle into a planetary atmosphere demands the most meticulous attitude control.

Presently conceived techniques of attitude control for space vehicles include the use of gas jets and inertia wheels. Gas jets, working in pairs, are small rocket nozzles which rotate the vehicle by reaction. Force generated by the jet causes an angular, or rotational, acceleration of the vehicle. The duration of the firing of the jet controls the amount of rotation. Of course, the opposite jet must be fired to stop this rotation of the space craft.

Inertia wheels work similarly. As a wheel is spun up in one direction, the opposing force reaction causes a rotational acceleration of the space craft. The slowing of the inertia wheel also slows the turning of the vehicle.

Because there is no air to damp motions, the attitude control system must respond quickly and operate almost constantly. Any slight disturbance, such as the impact of micro-meteorites or the movement of any machinery, equipment, or crew will cause the vehicle to rotate and will require corrective action by the attitude system.

Directional and speed control demand much larger control forces. Because the concept of velocity includes both direction and speed, the term *velocity control* often denotes control of either or both of these effects. Velocity control is necessary for injecting a vehicle into an orbit or onto a desired trajectory. Velocity control will also be necessary for correcting trajectories in mid-flight. Ejection from orbit, or landing on a planet will require velocity control to avoid burning up in the atmosphere or crashing into the planet.

Control of velocity during space flight is achieved by firing up a rocket engine or other propulsion device, and controlling both the length of time of firing and direction in which the rocket engine is pointed.

Firing the rocket engine accelerates the vehicle in a direction determined by the angle of the rocket thrust with relation to the path of the space craft. The integral of this acceleration, with respect to the length of time of firing, is a correction velocity. The resulting speed and direction of the space craft is the vector sum of the original velocity and correction velocity. The diagram shows a typical turning maneuver in space.

ATTITUDE CONTROL

If gas jets are used for attitude control, no hydraulic power need be used. However, the excellent torque-to-inertia ratios of hydraulic motors might make them the most suitable for accelerating inertia wheels. Studies tend to indicate a superiority for hydraulics if the power requirements exceed about one horsepower.

• **Velocity Control**—Velocity control is achieved by (1) controlling the length of firing of a propulsion device such as a rocket engine and (2) by controlling thrust direction of engine exhaust. Simple valve operation should control the time requirements. Control of thrust direction is achieved by moving jet vanes in the hot exhaust stream, by swiveling the whole thrust chamber or by rotating jetavators. These techniques are shown in the diagram.

Thrust direction control requires rather large forces because of bearing friction, misalignment of thrust chambers, and structural deflections. With large rocket engines, the inertia of the moving element can be an appreciable part of the total load. In the past, the size of these loads and the precision of control required for them has justified the use of hydraulic servosystems.

• **Environment**—Having established the possible need for hydraulic power for attitude control and its probable need for velocity control, the next consideration is a study of the compatibility of hydraulic power with the space environment. Among the new environmental factors to be met are:

- Absence of atmospheric pressure
- Lack of chemically active atmosphere
- Solar radiation
- Nuclear radiation
- Temperature extremes

The first two of these can be considered together. The absence of atmospheric pressure means that hydraulic fluids must either have very low vapor pressures or must not, in normal use, contact the space environment. The boiling off, for instance, of the thin film of oil on an actuator rod would leave residues that would soon ruin shaft seals. The lack of oxygen also imposes a hardship on the hydraulic power system. Oxidation of metal surfaces is a major factor in lubrication. The lack of oxided bearing surfaces will tend to increase the friction loads which the hydraulic power must overcome.

Solar radiation does not appear to be a hazard. In fact, it might well be a significant source of in-flight power. Space travel between the inner planets should not create temperature problems if simple techniques such as rotating the space craft are used. However, landings on the dark side of the moon might require heating to prevent fluids and seals from freezing.

Nuclear radiation, especially in such areas of concentration as the Van Allen belts could be a real hazard to orbiting, un-manned vehicles. However, hydraulic fluids and system materials can withstand many times the nuclear radiation levels which kill people. Therefore, the hydraulic system should not suffer from radiation during normal operation of manned space vehicles.

• **Flight Times**—Two other operational factors may have a great effect on the use of hydraulic power in space craft. These are (1) the very long flight times associated with inter-planetary travel and (2) the difficulty of performing in-flight maintenance on the hydraulic system.

The literature[1] describes flight times for minimum-energy trajectories ranging from 110 days for a trip to Mercury to 46 years to the outer planet, Pluto. Because of the need to wait for the most advantageous positions of the planets before starting a return trip, the minimum round trip time between Earth and Mars would be 2 years and 244 days! Such long trip times place a tremendous premium on hydraulic system reliability.

While aircraft hydraulic systems have an excellent record of reliability, military studies[2] indicate that this reliability is—at least in part—the result of excellent maintenance operations. Such fine maintenance probably would be difficult or impossible during a prolonged space cruise.

• **Reliability**—Perhaps the single most worrisome factor in the use of hydraulic power during space flight will, then, be the assurance that the hydraulic equipment will work when required, during extremely long flight times. Probably, little or no system or component maintenance can be assumed.

The concept of military reliability most generally accepted is based on the rate of random failures which occur during a period after manufacturing errors have been caught and before wear-out begins. The inverse of the random failure rate is the Mean Time Between Failure (MTBF). The probability of proper functioning (reliability) of the equipment during any operating period is then

$$R = e^{-\frac{t}{T}}$$

where R = Reliability
e = Base of Naperian Logarithms
t = Operating time
T = Mean time between failure.

Thus, reliability increases with increasing MTBF and decreases with increasing operational time. This technique of reliability prediction has been thoroughly established in the use of electronic equipment.

• **Hydraulic Equipment Reliability**—Some conceptual difficulties arise when trying to apply these reliability theories to hydraulic equipment. A prime difficulty is that a failure, or series of failures in mechanical or hydraulic equipment is usually considered a *design* problem. This attitude stems from the lesser

TABLE I

	HOURS TO FAILURE
Accumulator	4,200
Flight Control Actuator	2,800
Utility Actuator	4,250
Fittings	150,000
Quick Disconnects & Swivels	12,500
Heat Exchangers	7,100
Filters	14,500
Hoses	168,000
Oil Lines	45,000
Hydraulic Motors	6,900
Pressure Gages	7,400
Motor Driven Pumps	2,200
Engine Driven Pumps	1,300
Reservoirs	21,000
Check Valves	12,300
Relief Valves	30,500
Selector Valves	5,000
Shuttle Valves	10,200
Servovalves (mechanical)	4,800

number of hydraulic pumps, for instance, compared to the number of resistors or capacitors used in military vehicles. The pumps tend to be considered as special purpose items while the electronic components are thought to be mass produced. As a result, field failures of pumps may lead to a quick design change. Service data rarely refer to large numbers of identical hydraulic hardware.

However, if we can assume that similarity exists among types of components, then enough grouping into classes can be made to allow for some gross reliability studies. In addition to the service information given in the BuAer[2] report, reliability data in grouped form are presented by Knight[4] and Johnston and McRuer.[5] However, the later studies appear to be heavily based on the BuAer report.

A survey of the literature yields values of mean time between failures for aircraft hydraulic components shown in Table I. Most of these data were drawn from the BuAer report. Parenthetically, many people responsible for military hydraulics feel that these values are unreasonably large.

A real need exists for better and more up-to-date mean time to failure data for hydraulic components. For example, an analysis of modern electrohydraulic servo actuators for a bomber aircraft yields a MTBF of 450 hours.

TABLE II

ELEMENT	RELIABILITY 5 Hours	5 Days
Pump	.99644	.91202
Check Valve	.99940	.99030
Filter	.99969	.99180
Relief Valve	.99984	.99608
Reservoir	.99978	.99433
Servo Actuator	.98898	.76596
System	.98418	.67953 MTBF 310 Hrs.

To understand how these numbers are used, we can establish some hypothetical requirements for aerospace vehicles. Let us assume:

(1) An experimental orbiting flight consisting of boost, a short orbiting time and a re-entry and landing. The total flight time is five hours. Hydraulic control is needed during the whole flight.

(2) A flight to the moon and back. The total time is 5 days. Hydraulic power is needed for rocket engine control during boost and re-entry and for attitude control during cruise.

(3) An orbiting astronomical station requiring hydraulic power for boost, orbital insertion and accurate attitude control. In each case consider a simple hydraulic system composed of a pump, check valve, filter, relief valve, electrohydraulic servo-actuator and reservoir. These components are connected in series. fashion by completely reliable tubes and fittings. Individual reliability figures are computed by the formula above. The system reliability, for a series arrangement is obtained by multiplying the individual reliability figures together. These figures are given for the five-hour and five-day flights in Table II.

These numbers indicate that, even with the very simple system described, the probability of success—while satisfactory for the short five-hour flight—would be only two out of three for the moon trip. The system MTBF figure of 310 hours suggests that the hydraulic system on the astronomical satellite will fail in thirteen days. More complex systems would fail even sooner. Clearly, hydraulic systems of this nature are not reliable enough for extended space flights.

• **Improving Reliability**—How can the reliability of hydraulic equipment be improved? To start off, better knowledge of reliability figures for present-day components is needed. Then, improvements in reliability can come from improved component design, manufacture, and handling, and from systems designed with reliability in mind.

Even with the questionable reliability data now available, pumps, electrohydraulic servovalves, and flight control actuators are obvious areas of early failure. This is not news to most fluid power and autopilot engineers. What *is* new is the need for design for re-

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liability rather than the design for low price, for small size, or for light weight. Also required will be a better understanding of representative testing methods for flight control hydraulic hardware. Reliability criteria and methods of demonstrating reliability may be necessary for future procurement documents.

In parallel with the development of reliable components can be the understanding of designing systems for reliable operation. Some definite improvements in hydraulic system reliability can be achieved by selective redundancy of elements and by use of failure monitors and switching devices. ▼▼▼

Hydraulics on the moon

• By **A. BLOCH**, *Engineering Mechanics Manager*, and **A. KONSTANTIN**, *Senior Development Engineer, Military Products Division, Singer Mfg., Co., Bridgeport, Conn.*

A MOON BASE in the next 20 years appears a certainty. It is necessary for future space travel and exploration, and probably, will use hydraulic systems, because fluid power provides economy and flexibility.

Moon-based vehicles such as tractors, and mining machinery will use hydraulics. So will landing and fueling equipment, telescope drives, shelter elevators and retractors. System economy and flexibility will greatly influence desiga criteria. The hydraulic engineer must understand how these criteria will affect his own designs.

• **Size and Weight** of all components will be of utmost importance, because it will cost about $600 per pound to land a nuclear engine on the moon with a 25,000-lb payload.

Gravity on the moon is 1/6 what it is on Earth. This should help the designer, because on the moon a cylinder will lift 6 times what it can lift on Earth.

• **Temperature** on the moon ranges from −240 F at night to +270 F during the day. While not all equipment will have to work at these temperature extremes, mobile equipment *will* have to withstand them. Stationary installations can be buried in the ground, where temperature is a constant −22 F, and hydraulic fluids will also be shielded from solar radiation.

Fluid selection will be particularly difficult. Multiple-fluid systems could be designed, with automatic switchovers at various temperatures. Or a heating and cooling system could keep the working fluid within its best operating temperature range. Because there is no air on the moon, heat transfer depends entirely on radiation. It will be necessary to protect above-ground installations from solar radiation during the day, and to keep them from excessive cooling at night. Components can be coated to control temperature and can be insulated with reflective insulating materials such as metal foil. Because there is no weather on the moon, the insulating materials need not be strong. However, the effect of thermally induced fatigue on all exposed parts must be considered.

The constant sub-surface temperature forms a heat sink which can be used to cool hydraulic fluids during the day (in stationary installations). A heat pump, operated by surface and sub-surface temperature differential, could heat the hydraulic fluids to keep them from freezing.

• **Radiation** from the sun's ultraviolet and X-rays will be strong because there is no atmosphere on the moon. Cosmic radiation, particularly during solar flare activity, will be much higher than on Earth, where it is largely absorbed by the atmosphere. Since it is not feasible to shield all above-ground components against penetrating radiation, materials that withstand radiation should be used for a moon base. Common structural metals can withstand the levels of radiation expected on the moon.

Ordinary petroleum-base hydraulic fluids change viscosity appreciably when exposed to radiation. Silicate-base fluids have more resistance, but should not be exposed to radiations greater than 1×10^8 R. Hose, gasket, and seal materials must have thermal stability, and fluid resistance. They must withstand radiation without deteriorating. Metal gaskets and seals may become damaged during extreme temperature changes.

• **Atmospheric pressure** being absent, leakage will be aggravated. Handling and transferring fluids will require special techniques. All storage tanks and reservoirs will have to be hermetically sealed.

In atmosphere, liquid vapor tension (tendency to vaporize) is balanced by vapor pressure in the immediately adjacent layer of atmosphere. When there is no atmospheric pressure, this layer does not stay in place, and fluid continually evaporates. For these reasons, all storage vessels will have to be col-

lapsable, or be pressurized by inert gas on the liquid surfaces.

• **Dust** makes up most of the moon's surface. To protect all exposed parts against abrasion and dirt contamination, boots or bellows will be required.

• **Meteoric Bombardment** rate and size on the moon is unknown. Compared with shelters and spaceships, the exposed areas of hydraulic components are small, and have little chance of being hit by a meteor. However, if a hydraulic line became damaged, all hydraulic pressure sources should be shut off automatically, and all accumulators and reservoirs sealed-off.

• **Power** to drive a hydraulic system is a major consideration. The absence of atmosphere makes solar energy a welcome source of power. It will require conversion to electricity and direct electrohydraulic pressure sources eliminating the conventional pump—motor arrangement.

Another source of energy is the temperature differential between the moon's surface and sub-surface. This energy will be available when we can invent a practical method of exchanging heat with the poorly conductive, lunar surface dust-soil. In large installations, a nuclear power planet would eliminate this difficulty.

• **g-loads** will affect components, carried to the moon but not used to operate the spacecraft. Systems used in flight, such as impact brakes, antennae and telescope retraction mechanisms will have to withstand high g-loading while they are in operation. All equipment will have to land on the moon in top operating condition.

• **Reliability** and economy must be very high, and maintenance a minimum. Systems must be designed with the least number of parts. This is particularly true of rotating and oscillating components. It is obviously impossible to duplicate the moon's environment on Earth. Therefore, intensive testing in an approximated environment, will be essential.

• **Standardization** and interchangeability of all hydraulic systems will be very important. Should one system fail, its parts could be used to repair another one. The number of different size lines should be kept small. The advantages of small, specialized components should be carefully weighed against simpler, heavier, but interchangeable units. Hydraulic systems should be designed on a modular, building-block principle. Initial moon trips will be infrequent, and parts transported on any one trip should be sufficient to build integrated, complete installations.

Exact conditions on the moon are still not known. The knowledge and experience we have in the fields of nuclear industry, missilry, and high-speed aircraft will help us design successful systems for the moon-based hydraulic components. ▼▼▼

What's ahead for hot gas servos?

• By **FRANK P. MLADINICH**, *Hydraulics/Pneumatics Chief, Grumman Aircraft Engineering Corp., Bethpage L.I., N.Y.*

ONE of the most interesting and challenging areas in fluid power control has been the hot gas servo system. A great deal has been published recently concerning the possible use of these devices in a control system. The concensus appears to be that they have distinct advantages over other systems. These advantages are lighter weight, more compact size, greatly extended storage life, and several others.

The simple appearance of the physical parts gives no indication of the formidable problems involved in fabricating, analyzing, and operating one of these systems as a quantity production item. Those who have succeeded in making units of this type operate successfully have discovered the demands made upon their capabilities in terms of materials selection, surface finishes, choice of supplementary equipment, etc. In spite of the design difficulties inherent in these systems, they still appear attractive, and for this reason hot gas servo systems are being proposed for more and more missile control systems. However, there are still problem areas that need either further study or further development. Let us examine some of these grey areas and take a look at some of the efforts that are being devoted towards resolving them.

• **Load Sensitivity**—One of the frustrating areas at present is the high degree of sensitivity of all gas systems to the characteristics of the load that they are designed to drive. Most of the work done thus far in the industry has been with assorted combinations of inertia loads and spring loads, with a small amount of friction thrown in. Those loads in which the major factor is friction—particularly where friction varies

from its maximum value to some value approaching zero—seems to be an area which still requires considerable investigation. While several ingenious techniques have been employed to circumvent this sensitivity, these gains have usually been made at the expense of added complexity to the system. What is needed is a simpler arrangement for coping with this load sensitivity, while still preserving the minimum number of parts and high degree of reliability which are some of the outstanding advantages of hot gas systems.

• **Contamination Sensitivity**—Very early in the design of a prospective servo system using the gas produced by the combustion of a solid propellant, the designer becomes aware that the dimensions and tolerances that he must use to limit gas flow are highly susceptible to clogging if any appreciable quantity of solid particles are allowed to flow through the system. Up to the present time, centrifugal swirl chambers, filters, and a variety of other methods have been used to prevent this unhappy occurrence. But these are makeshift remedies at best, designed to overcome a condition which ideally should not even be there. The proper solution to these difficulties would be the development of a combustible, high energy, solid material whose only product is a clean, hot gas without soot, tars, vaporized metal, and all the other by-products which are currently being produced. Several propellant manufacturers are now going forward on this problem, and it is hoped that an early solution will be forthcoming.

• **Temperature Sensitivity**—Hot gas system applications fall mainly into the following categories: seeker device positioning, turbine speed control, aerodynamic surface positioning, and thrust vector control. Each of these applications requires the servo system to operate in a hostile environment: heat, cold, and vibration in widely varying amounts. Most of the applications being considered involve the use of electrical devices: amplifiers, potentiometers, differential transformers, etc. Although mechanical feedback may be used in some cases to close the servo loop, there still remains the requirement of translating an electrical command signal usually consisting of a change in electric current into a control system movement. Electrical devices must be capable of operating in high ambient temperatures without thermal insulation. It is gratifying that considerable success has already been achieved along these lines by at least one research organization.

• **For the Future**—To summarize briefly, much progress has been made in a new field in a short time. The present state-of-the-art in hot gas servo system design allows its use for many successful applications. There are still many areas of development, some of which have been mentioned above, which would help considerably to ease the task of the hot gas servo system designer. There appears to be sufficient growth potential in the basic principle to keep up with the inevitable increase in the performance requirements as mission profiles and applications become more stringent.

It appears that the time has arrived to convert the basic principles of hot gas toward the development of components, the coupling of these components into defined and recognizable systems, and the use of these systems to operate specific loads to specific performance criteria. ▼▼▼

We need simpler design methods

• By **AUGUST S. LERMER** *Design Engineer, Convair, Div. General Dynamics Corp., San Diego, Calif.*

Simple, reliable engineering design methods are needed by space-age engineers to offset increasingly complex designs and to help establish stability criteria.

FLUID POWER engineers and technicians are aware of the impact space-age travel is making on fluid power. New materials have to perform satisfactorily in outer space. Hydraulic fluids and seals require a high degree of stability. They will have to be dependable and reliable regardless of temperature changes, nuclear radiation, or cosmic effects.

• **Systems Maintenance**—Servicing, checkout, and fluid power sequencing will become more complicated. Simple design and failproof equipment will be required to compensate for more complicated systems. Adequate service stations in outer space will not be available at first. Packaging and storing of fluid power service parts will also undergo many design changes.

It will be essential to keep systems in optimum operating condition, during a maximum length of time.

Maximum operating time will require minimum out-of-service time for maintenance, repairs, and overhaul. Remote control might be used for built-in automatic maintenance.

New fluid power applications will operate complex control systems for boosters and sustainers of missiles and space ships. Boosters and sustainers will in turn draw their power requirements from organic, exotic, nuclear, or other fuels. How can designs be simplified so engineers of fluid power systems can handle them with ease?

• **Reliability Criteria**—Present hydraulic and pneumatic control systems are becoming more and more complicated. This increases the need to establish reliability criteria that can be used as a yardstick to predict stability and safe performance under adverse operating conditions.

The criteria exist, but require a thorough knowledge of calculus, servomechanisms analysis and circuit analysis. Many hardware and systems designers lack this background, and are unable to calculate system and component performance. New stability criteria are needed that will be as reliable as the criteria existing today. They need to be simple enough to be used by men with limited educational background. These new criteria must be as reliable, however, as those based on calculus so they may become standard tools, to be used by highly skilled technical personnel.

• **Simpler Design Methods**—Some simplified methods already exist. Soon, they will enable the average designer to calculate control system stability without need for advanced academic training. These methods will make it possible to solve complex problems easier, faster, and with more certainty. ▼▼▼

Built-in reliability

• By **GRADY GILDER JR.**, *Hydraulic Engineer,*
Vought Aeronautics Div., Chance Vought Aircraft, Inc., Dallas, Texas

Hydraulic system reliability can be improved by integrating hydraulic components into the vehicle's basic design.

A SYSTEM is reliable if it performs when required. System reliability can be improved by analyzing materials, servicing, deterioration, contamination, and installation. Above all, design thinking must always be reliability-oriented.

• **Reliability Yardstick**—How much reliability can be designed into a system? Unfortunately, engineers do not agree on reliability standards. To control the reliability of an entire system, a designer must consider these four areas: (1) system function, (2) component design, (3) installation, and (4) system connections. System reliability must be integrated into the design. That means the hydraulic system must be engineered at the same time as the supporting structure. This is the first big step in producing an integrated system design.

• **Integrated Design**—A man's heart pumps blood to all parts of his body through arteries, veins and capillaries. To protect the arteries from external damage, they run along the body skeleton. Why not design hydraulic systems the same way? Make most of the fluid lines permanent parts of the supporting structure. This reduces chances of damage, and greatly increases reliability.

• **Packaged Design**—A fully integrated fluid system would have transmission lines or flow passages permanently attached or integrated into the structure. This would protect the lines from external damage, and make them as reliable as the structure. The system's operating components would be grouped into unit packages and fed by the main trunk lines. They would be mounted in accessible places. The packages would be connected so they could be installed or removed easily and without loss of fluid. The production department could inspect and service the packages before installing them. The only fluid leakage points requiring maintenance would be the joints between the packages and the system's permanent parts.

• **Disadvantages of Modular Design**—Also to consider in the design of unit packages is that design will take longer, and will be less flexible. Changes will be harder to make. The system will have to be tested and proved before it is built. Design time and research will be more expensive, but savings from a reliable system will pay for it. It has been argued that more design time and effort is not available, and is too expensive. Consider, then, how much unnecessary time and effort is spent to improve systems that were rushed through as crash programs without adequate thought and design. One is reminded of the engineer who wondered why there was never enough time to do a job right, but always enough to do it over. ▼▼▼

To handle Thiokol Chemical's solid propellant rocket engines, Hufford designed this giant mobile crane. Hydraulic boom and crane handle 40-ton engines with dexterity

Pilot control for pressure sequencing

• By **FRED J. WEIR,** *Design Engineer, The Hufford Corp., El Segundo, Calif.*

THE 16-inch cylinders which raise the Transrector's boom go through four pressure phases during raising, and even have to retract at the beginning. Erecting force has to be applied smoothly to keep the 54-ft. boom from oscillating. Pilot control was selected to sequence the circuit through these phases. It avoids large expensive solenoid valves which would have to be explosion proof. The only electrically controlled valves are those which are connected into a portable console.

The Transrector has to pick up an engine (up to 88-in. diameter, 35-ft. long) from any position and carry it to the test site. It must then lower the engine into a pit 30-ft. wide, place it against a wall, or shift it onto a flat car.

Dollies riding in tracks support the engine. The double boom mounts a 50-ton hoist powered by two fluid motors, driving through speed reducers.

Boom hoisting is started by two 3-stage telescoping cylinders. These raise the boom until the 250-in. stroke main cylinders are in position to take over.

With the boom in position, two cylinders mounted at the top of the boom swing out supporting legs to form an A-frame with a 37-ft. span.

Hydraulic power is from a 60-gpm, 2,000-psi, gear pump driven by a 160-hp diesel engine. The engine also drives a 40 KW generator. A similar generator-pump arrangement is driven by the 330-hp tractor engine. Governors keep both engines at 1800 rpm during handling operations.

Fifty-ton jacks, driven by fluid motors, are at each corner of the trailer. Control is from a portable con-

sole with a 50-ft. cord to allow freedom in working from the best position to view operations.

• **Telescoping Cylinders Start Erection**—When the boom is stowed as shown in the diagram, the main cylinders are lying horizontally, with the thrust vector below the boom pivot point, creating a toggle locking action. The cylinders must retract to allow for the telescoping cylinders to lift the boom. Cam valves *A* shown in the circuit diagram are actuated and allow pilot oil to open valve *B* and shift valve *C*. This blocks system pressure and connects reduced pressure fluid to the main cylinders. Also the main cylinder counterbalance valves are piloted open. Shut-off valve *D* opens on a signal from the console.

Valve *E* is held energized by a limit switch in the control console, and applies pilot pressure to valve *F*, locking out flow to the telescoping cylinders. When the operator starts the raising cycle, the limit switch opens, dropping out valve *E* solenoid and opening valve *F*.

Pump outlet, regulated by spool position of valve H, enters the telescoping cylinders to start raising the boom. Pressure on the cylinders opens valve *G* which connects the rod and head ends of the main cylinders together. With reduced pressure on both ends of the main cylinders, they are forced to retract one-half inch as they move from point *A* to *B* (on the cylinder diagram). Excess oil from their head ends passes to tank through valve *B*.

As the telescoping cylinders raise the boom, the main cylinders are pulled out from point *B* to *C*. At point *B*, cam valve A_1 shifts. This closes valve *B* and forces 100-psi oil into the main cylinder head ends. The main cylinders extend in a differential circuit with rod-end exhaust helping to fill the head ends. Main cylinder pressure is approximately 50 psi.

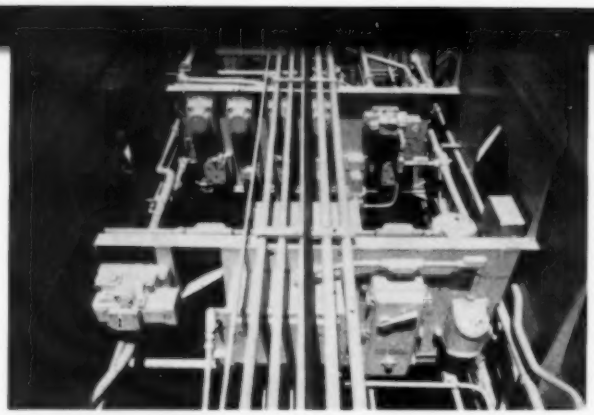
• **Cam Valve Pressurizes Main Cylinder**—The telescoping cylinders reach the end of their strokes at point *C*. Cam valve A_2 shifts and applies pilot pressure to the spring side of valve *C*. Valve *C* shifts to block reduced pressure oil and connect full pump output to the main cylinders. The main cylinder counterbalance valves are no longer held open by pump pilot pressure.

The rod end of the telescoping cylinders are not attached directly to the boom. A ball end on the rod end and a socket on the boom transmits the thrust of the cylinder. The track guides the rod end into the socket on the boom.

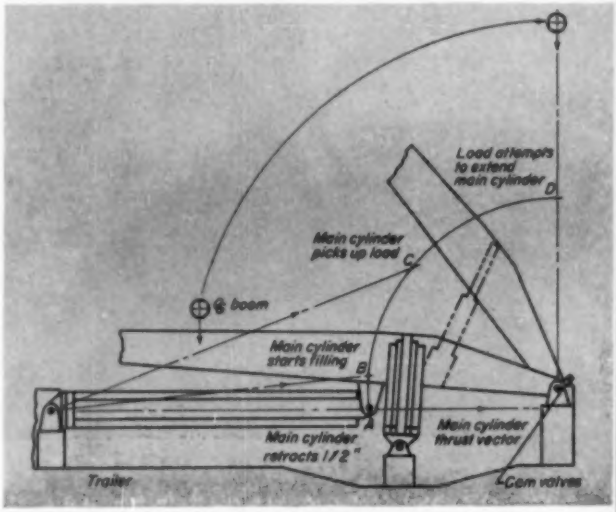
As the main cylinders drive the boom upward, the boom's center of gravity passes beyond its pivot point (point *D*). This over-center condition would allow the boom to free fall until the main cylinders were fully extended, but counterbalance valves create a resisting pressure, so that the cylinder must extend under a reduced, but positive pressure.

When valve *H* is centered, pump pressure drops to 300 psi which is maintained by a sequence valve to insure adequate pilot pressure. The counterbalance valves hold all cylinders by blocking flow.

With the boom erected, the suporting legs are swung out by cylinders. The boom is then positioned further over center until the legs rest on the ground as a support.



HYDRAULIC VALVES and electrical controls are mounted on trailer cross members between 40-in. beams. Top flanges of beams are machined as tracks for the engine dollies.



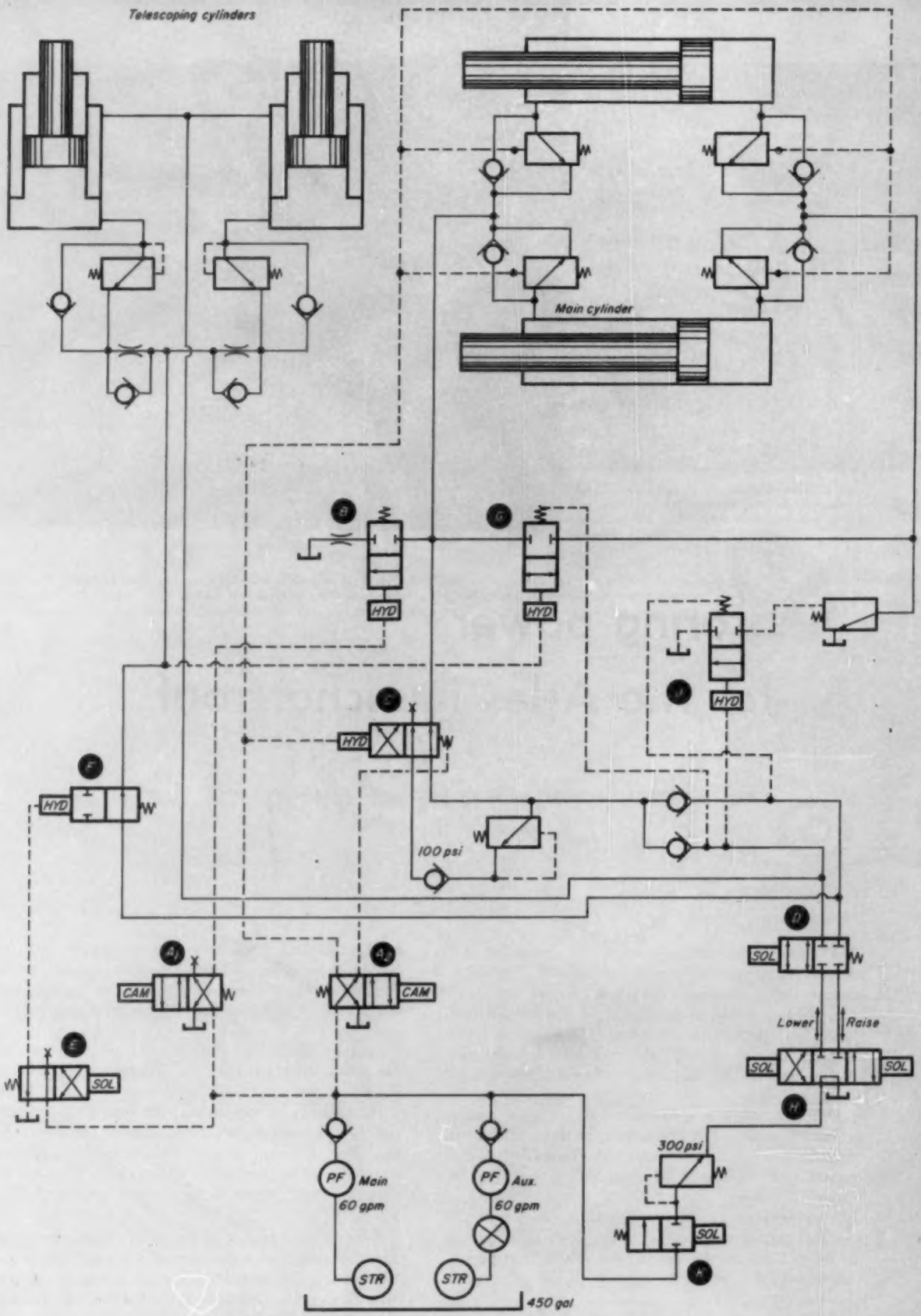
AS TELESCOPING CYLINDERS LIFT boom main cylinders retract (from A to B), then are pulled out (from B to C). At C, main cylinders are pressurized by cam valves to raise boom. Over-center condition at D is counterbalanced by valves.

• **Counterbalanced Lowering**—When valve *H* is shifted to lower the boom, valve *G* loses its pilot pressure and closes. At the same time, valve *J* opens, venting the relief valve allowing main cylinder head end oil to flow to tank.

At point *C*, cam valve A_2 shifts so that the main cylinders again float with head and rod ends connected together under 100-psi pressure.

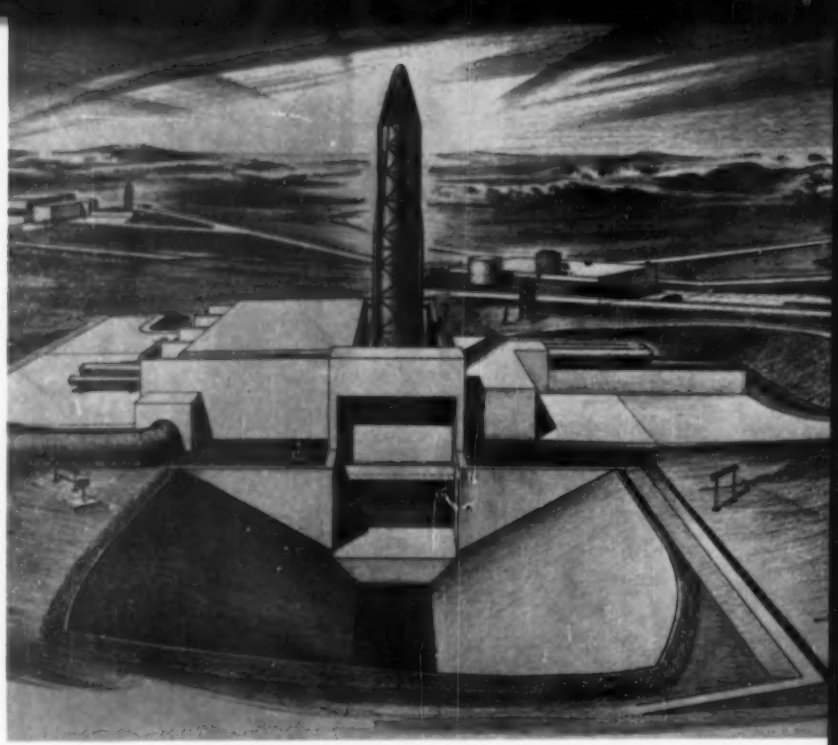
The telescoping cylinders have been held extended by their counterbalance valves. Even though system pressure has been applied to retract the first stage, the valves are set high enough to prevent this. However, when the boom weight settles on the telescoping cylinders, pressure rises above the valve setting and the boom drops at a rate determined by the flow control valves. The boom can be stopped and held at any time during this operation by shifting valve *H* to neutral. Valve *E* is then energized to actuate valve *F* which closes to prevent further movement.

As the boom passes point *B*, cam valve A_1 shifts, opening valve *B* and depressurizing the main cylinder circuit. The boom continues its downward travel until it rests against the boom supports. ▼▼▼



BOOM CIRCUIT is controlled by 300-psi pilot pressure. Pumps also supply circuits for operating crane, spreading support legs, locking the dollies, and jacking the trailer.

700 hp must be available for fast delivery to unlatch and raise the 400-ton roof of this Atlas launcher building. An accumulator system was the natural choice. Special controls insure reliability.



Storing power for the Atlas launcher roof

• By **J. E. MUNROE,** *Vice President, Paul-Munroe Hydraulics, Bell Gardens, Calif.*

THE MOST important factor in the design of this accumulator system was dependability. The infrequently used accumulator must always be fully charged and ready to quickly move the 400-ton roof that covers the launcher building. The system is being installed at each of nine semi-hard Atlas missile complexes now being built near Cheyenne, Wyoming. Latch cylinders lock the roof to the outer walls of the building to prevent movement in case of a nearby atomic explosion. Lift cylinders raise the roof three to four inches after it is unlatched. Then the roof is pulled aside on tracks by a car puller, exposing the Atlas.

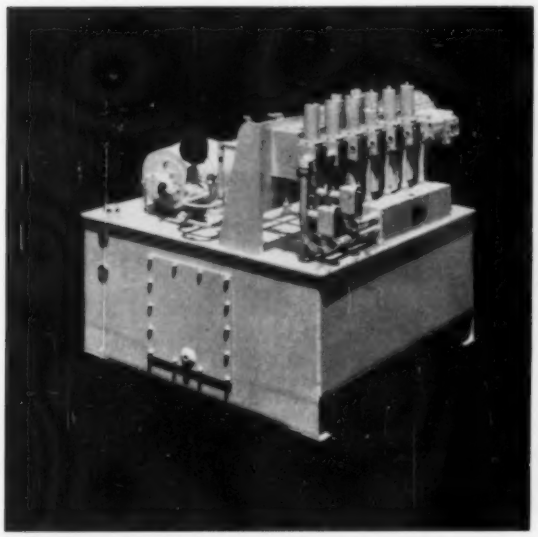
Specifications called for unlatching the roof in 1 sec and raising it in another 3 sec. Total opening time is 30 sec. 700 hp was needed for only a brief period. Obviously, this is a good application for an accumulator system.

• **Maintaining Pressure**—The accumulator had to remain charged for indefinite periods without actuation. This required an alarm system to indicate gas or oil leakage and a method of maintaining the pressure.

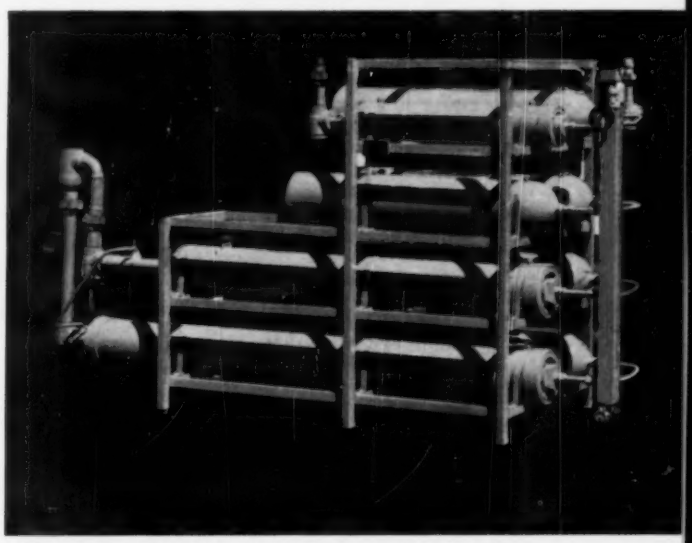
Leakage is sensed by monitoring oil pressure, accumulator piston position, and piston oil leakage to the gas side of the unit.

Oil pressure is the easiest to monitor. A pressure switch is connected into the oil side of the accumulator. This pressure switch automatically stops and starts the pump motor, so accumulator pressure remains within 100 psi of the desired setting of 2700 psi.

Sensing accumulator piston position was more difficult. Piston type accumulators are used with a gas bottle storage system. By using gas bottles it was possible to size the accumulators so that the piston almost

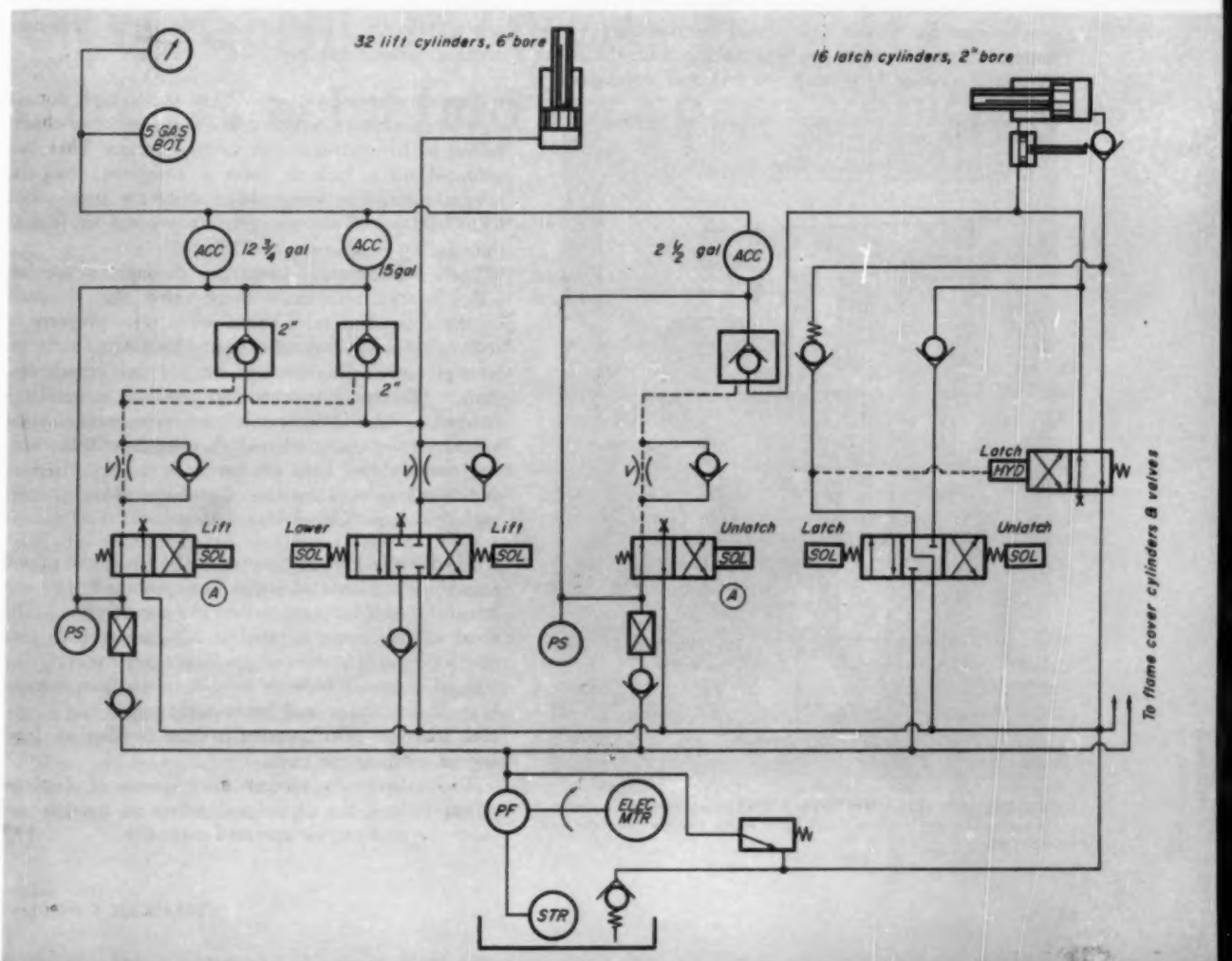


HYDRAULIC POWER SOURCE and control panel use a common drilled subplate, eliminating most piping. Each of nine semihard launching buildings at Cheyenne is supplied by a power unit.

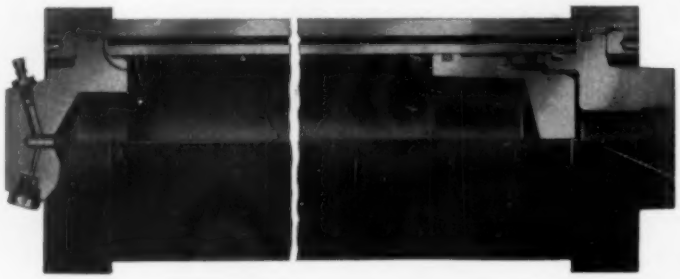


ACCUMULATOR RACK combines three, double-shelled piston acumulators with five nitrogen gas storage bottles. An alarm pressure switch mounted on the rack closes when pressure drops to 2580 psi from the normal 2700 psi.

CIRCUIT OPERATION: (a) Eight flame-tunnel-cover latch cylinders retract to unlock the cover from its foundation. (b) Four lift cylinders raise the cover three inches. It then rolls back to exhaust spent fuel gases. Accumulators are not used, because fast opening is not important. (c) Latch and lift cylinders for the roof are actuated from the accumulators in the same sequence.



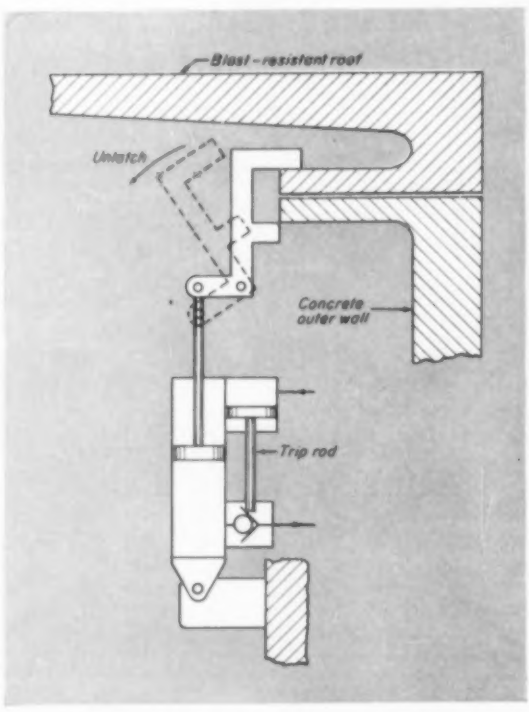
THE ACCUMULATOR'S OUTER SHELL **is a gas container and a protective cover, so that damage from rough handling will not interfere with piston movement within the inner shell. The inner shell is surrounded by gas and is pressure-balanced. The piston has two standard O-rings: the gas ring seals and the hydraulic ring guides. The accumulator piston is drilled from the hydraulic end through to the undercut. This provides equal pressure on each side of the O-rings and prevents extrusion and pressure lock between the O-rings. Hydraulic fluid in the undercut lubricates the O-rings. A dashpot decelerates the piston at the end of its stroke. This reduces hammer.**



Accumulator temperature drops when the hydraulic fluid discharges rapidly. Gas surrounding the inner shell acts as a coolant during decompression. During rapid cycling, the accumulator must reach ambient before re-cycling. *Courtesy Superior Hydraulics Div.*

touched the end of the accumulator when the system was fully charged. Only five to six percent of its travel remained. If the piston bottoms in the accumulator, it indicates that either the pressure switch controlling the pump motor had failed, and the system was over-pressurized, (This would be obvious because the power unit would be running continuously.); or nitrogen gas was leaking from the accumulator system. If a small gas leak had developed, with further leakage, gas pressure would then drop below the oil pressure. At the danger point a gas pressure switch then rings an alarm.

As the final control, oil leaking by the accumulator piston drains down the gas manifold and is collected just above a shutoff valve at the low point of the gas system. Routine bleeding of this valve indicates whether leakage has occurred.



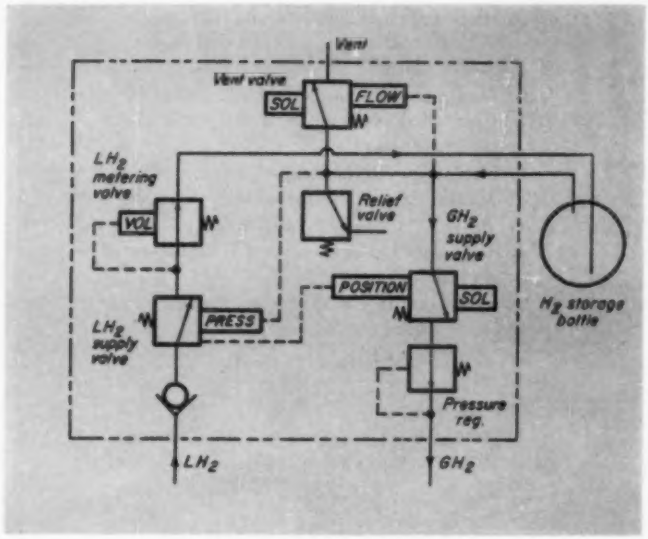
UNLOCKING HEAD SWINGS AWAY when latching cylinder retracts. Trip rod unseats check valve which secures head during inactivity.

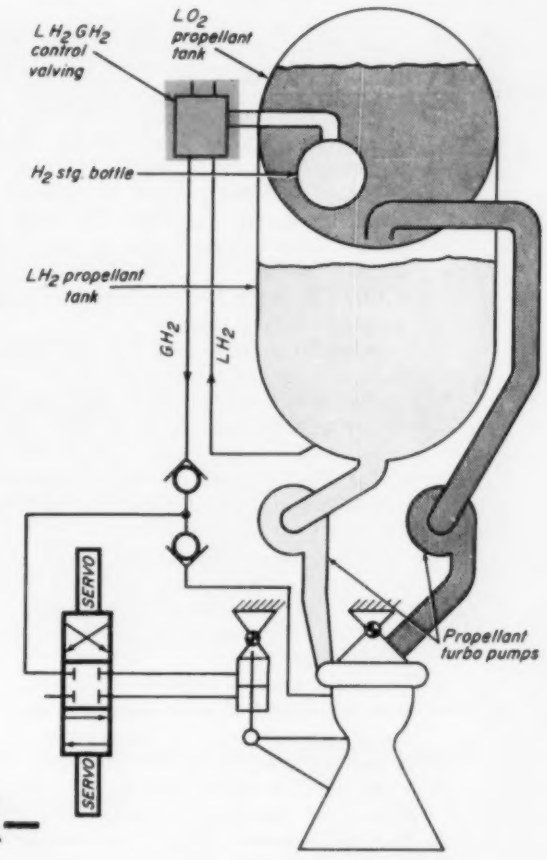
• **Accumulator System**—Three, piston type, double shell accumulators, totaling about 30 gal, are manifolded to five nitrogen gas storage bottles. They are mounted on a rack to form a complete, compact, integral unit. The accumulator units are precharged with 2000 scf of dry nitrogen (to prevent ice formation during discharge) to 2150 psi.

Each accumulator discharges through a special, pilot-operated, solid-spool check valve, also mounted on the rack. The valve opens when pilot pressure is *removed*. The spool remains seated because of accumulator pressure acting through valve *A* (see circuit diagram). The spool unseats and releases accumulator flow when valve *A* is actuated, removing accumulator pressure from the check valve's pilot line. These special check valves have proved to be a very effective and economical substitute for large flow, shutoff valve and are extremely fast acting.

• **Hydraulic Power Supply**—The hydraulic pump, reservoir, and control panel are combined into one integrated unit for compactness and simple piping. The fixed volume pump is rated at 2.2 gpm at 1800 rpm and 3000 psi. It is driven by a 3-hp electric motor. The 100-gal reservoir is large enough to dissipate normal heat. It has upper and lower sight gages and a special, micronic filler-breather-strainer to filter air leaving or entering the tank.

To discharge the accumulators in case of electrical power failure, the directional valves to unlatch and raise the roof can be operated manually. ▼▼▼





CRYOGENIC POWER– cold gas actuation for space vehicles

• By **H. D. DAVIS,** *Group Engineer, Hydraulic Design*
Convair (Astronautics) Div. General Dynamics Corp., San Diego, Calif.

THE EXTREMELY low temperature environment produced by liquid fuel and oxidizers in rockets presents a new set of problems for accessory systems. Hydraulic systems using fluids are left out in the cold. For simple missions like a single firing into elliptical orbit, refire into circular orbit, or parking and refire into probing operations, the hydraulic system can either be insulated, or heated with little power. However, for interplanetary operations such as Mars or Venus orbits which require long coast periods (roughly 120 days for Mars, 65 days for Venus) battery drain for heating is prohibitive. For example, the Venus flight would require a battery weight of .83 lb/BTU/hr; the Mars flight, a weight of 1.53 lb/BTU/hr. For the average hydraulic system this may mean a deadweight expenditure of 10-100 pounds depending on system heat loss in BTU/hr.

There are many solutions to this problem, but one worth considering is a cold gas servo system powered by one of the propellants. Two sources of gasified propellant are usually available: bleed-off from the engine cooling system, and vaporization of liquid propellant. Engine cooling gas can be used directly. It is at a pressure slightly higher than the combustion chamber pressure (350-500 psi). Its temperature depends on energy transferred to it before bleed-off and may be approximately 300 R. The second gas source would require more equipment to supply a servo system. The schematic of a dual source system is shown above with a more detailed circuit of the LH_2/GH_2 valving.

• **Cold Gas Servo System**—Gaseous hydrogen (GH_2) is supplied from the engine bleed point to the servo system through a shuttle valve. On engine ignition, gas flow builds up, slightly lagging thrust build-up.

For the stored gas source, a flask filled with liquid hydrogen (LH_2) is installed in the liquid oxygen (LO_2) propellant tank. LH_2 in the flask evaporates by

heat transfer to the higher temperature LO_2. The gas is stored at LO_2 boiling point (about −297°F depending upon LO_2 tank pressure.) This method provides a guaranteed heat source for vaporization of LH_2, regulates conditions of the GH_2, and prevents loss of gas from excessive heating and over pressurization.

The LH_2/GH_2 control valving, mounted outside the LO_2 tank has seven functions:

1. A check valve prevents back flow of fluid from the system into the propellant tank.
2. A pressure-sequenced shut-off valve permits LH_2 flow under LH_2 tank pressure after the storage bottle has been vented to atmosphere. The flask can only be charged while the vehicle is accelerating. Otherwise, hydrogen may not be available at the bottom of the propellant tank.
3. A metering valve, similar in principle to a hydraulic fuse, passes a fixed volume of LH_2 to the storage bottle. This amount corresponds to the weight required to operate the servo system throughout its complete duty cycle.
4. The vent is solenoid actuated to begin the charging. It is interlocked to close near the start of LH_2 charge into the bottle. Its closing time is affected by flashing effect as the LH_2 slug enters the flask.
5. A safety relief valve, sensitive to bottle pressure protects the flask from overpressurization.
6. A solenoid-operated, GH_2 release valve perimts GH_2 flow to the servo system. An interlock to the LH_2 shut-off valve prevents simultaneous flow of LH_2 into the system and GH_2 out of the system. This would permit flow of LH_2 into the servo system with the danger of flashing to high pressure. This would also upset charging a properly sized slug of LH_2 into the bottle.
7. A pressure regulator in the GH_2 line regulates pressure in the servo system.

The servo actuating system uses a conventional 4-way servovalve and balanced linear actuator. The system can be adapted to 3-way operation.

The conventional linear actuator is a potential source of dynamic instability especially because of low supply pressure in this system, permitting a low effective actuator spring rate. The gimballed thrust chamber also has considerable mass. These two factors result in a low natural frequency ($\omega_n = \sqrt{K/m}$) of the spring-mass system. A simple solution to the problem is to use a ball-screw jack driven by a motor, or a nutating plate motor. This prevents the heavy gimballed mass from affecting the compressible gas.

• **Sizing Components**—Let's get a rough feel for sizing the system, by assuming a hypothetical requirement for space vehicle flight control. The following information is available:

1. Vehicle data:
   An upper stage vehicle using a LH_2/LO_2 rocket engine.
   Thrust vector control of gimballed engines in two planes per engine.
   Mission sequence: 400-second firing after staging, 65-day coast period, 100-second refire.
2. Engine and flight control system data:
   a. Maximum dynamic gimbal torque: 985 lb-ft
   b. Gimballed mass moment of inertia about gimbal point: 60 slug-ft²
   c. Maximum engine displacement: ±3°
   d. Maximum gimballing velocity: 8°/sec
   e. Actuator outrigger radius: 12 in.
   f. GH_2 bleed available: 0.15 lb/sec @ 425 psia and 280°R
   g. Flight control system duty cycle: 50% of peak

Dynamic force output is:

$$F = \frac{985 \text{ lb-ft} \times 12 \text{ in/ft}}{12 \text{ in.}} = 985 \text{ lb}$$

Assuming a 33% pressure drop in supply pressure in the 4-way servovalve at rated flow, actuator area is:

$$A = \frac{3}{2} \times \frac{985 \text{ lb}}{425 \text{ lb/in.}^2} = 3.48 \text{ in.}^2$$

Half stroke of the actuator is approximately:

$$s = r\theta = 12 \text{ in.} \times \frac{3° \times \pi}{180°} = .628 \text{ in.}$$

Maximum piston velocity is:

$$v = r\theta = 12 \times 8°/\text{sec} \times \frac{\pi}{180°} = 1.68 \text{ in./sec.}$$

Gas volume per stroke is:

$$V = Av = 3.48 \text{ in.}^2 \times 1.68 \text{ in./sec.} = 5.85 \text{ in.}^3/\text{sec.}$$

Gas volume throughout operation at 355 psia and terminal temperature is:

$$V = \frac{5.85 \text{ in.}^3/\text{sec} \times 2 \text{ strokes/cycle} \times .5 \text{ duty cycle}}{1728 \text{ ft}^3/\text{in}^3}$$
$$= .00339 \text{ ft}^3/\text{sec}$$

If pressure drop through the servovalve is 70 psi in both flow directions, pressure to drive the actuator is 355 psi, and back pressure is 70 psi.

We find from a T-S diagram for hydrogen, density of GH_2 supplied from the engine at 425 psia and 280°R is .285 lb/ft³. Isenthalpic expansion through the servovalve very nearly approaches isothermal expansion. Therefore:

$$\frac{P_1}{\rho_1} = \frac{P_2}{\rho_2}$$

$$\rho_2 = \frac{355 \text{ psi} \times .285 \text{ lb/ft}^3}{425 \text{ psi}} = .238 \text{ lb/ft}^3$$

Weight of gas flow is:

$$W = .00339 \text{ ft}^3/\text{sec} \times .238 \text{ lb/ft}^3 = .000807 \text{ lb/sec.}$$

This is far less than the amount available from the engine.

• **Liquid Hydrogen Consumption**—The following assumptions apply to gas supplied from the storage bottle.

1. The bottle is immersed in boiling LO_2 under a pressure of four atmospheres (−268°F, 192°R).

Continued on page 86

Hand Pumps Still Provide Low Cost "Stand-by" Fluid Power

- Compact Pump-Valve Design
- Multi-Position Mounting
- Quick Pressure Build-Up
- Output Up to 1⅓ cu. in. Per Stroke
- Operating Pressures to 5,000 psi

COMMERCIAL hydraulic hand pumps are expressly engineered for installation on lower cost, utillty equipment sold for intermittent or "stand-by" service.

Typical applications are: (a) small highway trucks requiring a pump to operate cylinders that position snowplow blades used only seasonally, (b) fork-lift trucks, (c) tilt bed trailers, and (d) rotary tillers.

COMMERCIAL hand pumps are operated with little manual effort, and because they occupy small envelope space can be mounted in the most convenient operating position.

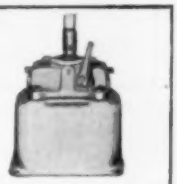
Many quality features insure trouble-free service often beyond the life of the equipment on which they are installed. Features such as: renewable steel check valve seats; pump plunger seats that absorb wear and can be easily replaced; stainless steel, spring-loaded check balls; and full porting to maintain ample oil supply.

All expendable parts are relatively inexpensive, readily obtainable and easily replaced.

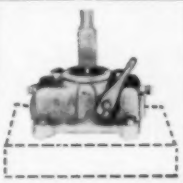
Hand Pump Performance Data

Model Number	Piston Dia.	Delivery Per Stroke (cu. in.)	Required Force (lbs.) on Pump Handle at Various Circuit Pressures (psi)					
			1000 psi	1500 psi	2000 psi	3000 psi	4000 psi	5000 psi
B301	9/16"	.2485	16	24	32	48	64	80
B304	3/4"	.4418	28	42	56	84	—	—
B307	1-5/16"	.6903	44	66	88	—	—	—
B309	1-5/16"	1.353	88	—	—	—	—	—

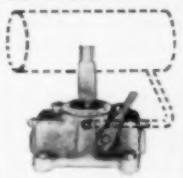
3 Types of Pumps Tailored to Your Installation Requirements



(A) Complete unit: Hand Pump-Valve, and integral oil tank in either ½ gallon or 1 gallon capacity. Four holes in base for mounting.



(B) Hand Pump-Valve... for top mounting to your tank.



(C) Hand Pump-Valve... with ¼ inch pipe tap at side of pump for connecting your low pressure hose and remote supply tank.

If you need a low initial cost, simplified hydraulic system to position components on your original equipment, it might well pay to investigate the COMMERCIAL line of long-life hand pumps and cylinders. Write for free Catalog H-1. Address: Commercial Shearing & Stamping Company, Dept. A-49, Youngstown 1, Ohio.

COMMERCIAL shearing & stamping

FLODAR

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5 exclusive features

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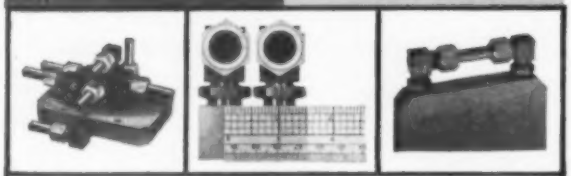
- Eliminates fluid system leakage
- No swing radius required
- No special seat preparation required
- Elbows and Tees can be positioned accurately



The FLODAR ***SELF-SEAT*** port fitting consists of a stem and body with a floating nut. Tightening the nut forces the stem into the seat making a leakproof, metal-to-metal seal.

The fitting body does not turn. Thus, fittings can be positioned close together — ⅛" fittings on 1" centers. Straight runs can be bench assembled.

SPECIFICATIONS

FLODAR ***SELF-SEAT*** fittings are available in sizes from ⅛" to 2" in steel, aluminum, brass, and stainless steel. All popular shapes are available.

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EASY TO INSTALL

To install, simply drill a pilot hole. Form the sealing step with an inexpensive drill or counterbore. Tap for a standard straight thread and tighten with a standard wrench.

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FAST DELIVERY FROM STOCKS IN ALL MAJOR CITIES

WRITE FOR ***SELF-SEAT*** *FLODAR CATALOG M-59*

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Pioneers In The Development Of Leakproof Fluid Systems

Circle **48** on Reader-Service Card

CRYOGENIC POWER

2. A 1000 in³ (.579 ft³) storage bottle is a convenient size for use in the missile.
3. Outlet pressure from the bottle is regulated to 425 psia.

For our first rough calculation we must find initial pressure in the storage bottle. Assuming that throttling through the regulator is isenthalpic, we again inspect the T-S diagram for H_2 in the area of −269°F. By following lines of constant enthalpy we find that the gas may expand from a considerable pressure without dropping in temperature more than 11°F. Let's assume that gas on the downstream side of the regulator is at 425 psia and −268°F. Its density at these conditions is .416 lb/ft³.

Let's also assume that enthalpy decrease of the expanding gas in the bottle is also zero. The weight of unusable gas left in the bottle is:

$$W_r = .579 \text{ ft}^3 \times .416 \text{ lb/ft}^3 = .241 \text{ lb.}$$

Total volume of gas discharged from the bottle at 355 psia and 192°R is:

$$V = .00339 \text{ ft}^3/\text{sec} \times 400 \text{ sec} = 1.36 \text{ ft}^3$$

Using our assumption of isothermal expansion through the servovalve,

$$P_1V_1 = P_2V_2$$

$$V_2 = \frac{355 \text{ psia} \times 1.36 \text{ ft}^3}{425 \text{ psia}} = 1.135 \text{ ft}^3$$

at 425 psia and 192°R.

Weight of gas discharged from the bottle is:

$$W_u = 1.135 \text{ ft}^3 \times .416 \text{ lb/ft}^3 = .472 \text{ lb.}$$

The total gas weight stored in the bottle is:

$$W_t = W_r + W_u = .472 \text{ lb} + .241 \text{ lb} = .713 \text{ lb.}$$

Since this weight of gas must be compressed into the .575 ft³ bottle, the density must be:

$$\rho = \frac{.713 \text{ lb}}{.579 \text{ ft}^3} = 1.231 \text{ lb/ft}^3$$

Storage pressure is computed from:

$$\frac{P_{425}}{\rho_{425}} = \frac{P_b}{\rho_b}$$

$$P_b = \frac{425 \text{ psia} \times 1.231 \text{ lb/ft}^3}{.416 \text{ lb/ft}^3} = 1258 \text{ psia @ } 192°\text{R}$$

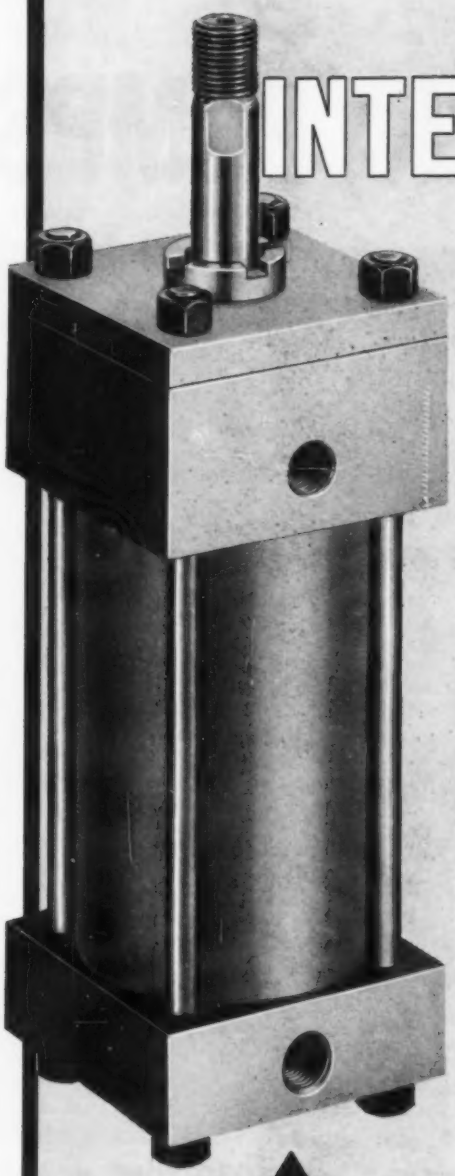
Returning to the T-S diagram, we see that an isenthalpic expansion from these conditions to 425 psia in the regulator would cool the gas only 7°F. Our error in isothermal expansion is negligible.

Finally, to size the metering valve which charges LH_2 into the bottle, we must determine the volume of LH_2 which will result in gas at 1258 psia. Assuming that LH_2 is stored in the main propellant tank at four atmospheres, its density is 3.92 lb/ft³. The volume of LH_2 is:

$$\frac{.713 \text{ lb}}{3.92 \text{ lb/ft}^3} = .182 \text{ ft}^3 = 314 \text{ in.}^3$$

From the above first-try calculations, we find that the amounts of gas consumed and the size of the components are feasible. The only remaining problems are

Concluded on page 96



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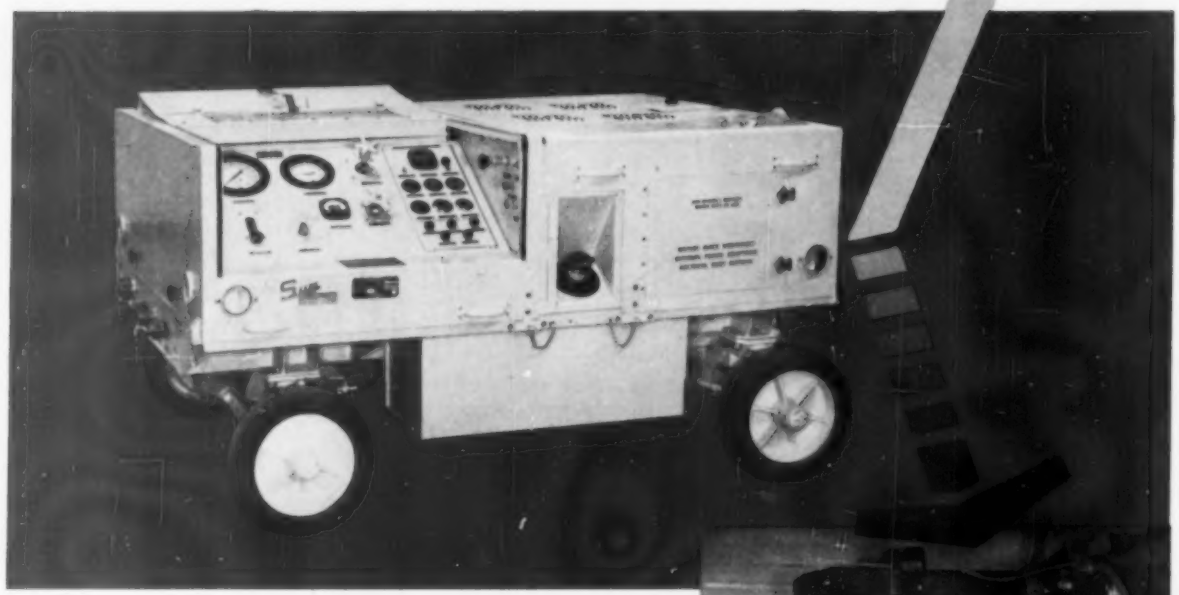

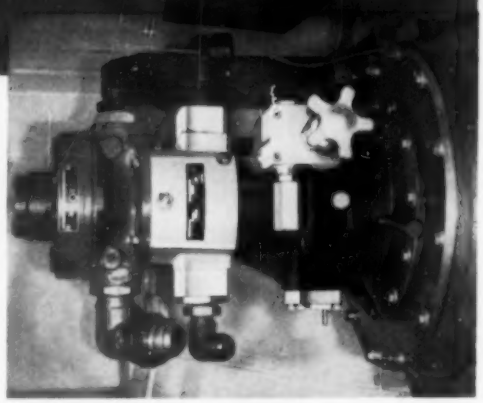

KLINE THRU-TORQ PUMP mounted on Model AHT-54A **Sun Test Stand** driving a **Gerotor** boost pump. Hydraulic lines removed for clarity.

Sun Electric Corporation, a leading designer and builder of hydraulic test stands, has selected the efficient and versatile new KLINE THRU-TORQ PUMPS to power their Model AHT-54A.

These KLINE PUMPS provide greater flexibility and truer simulations in Aircraft and Missile Ground Support applications.

By direct engine mounting, the KLINE THRU-TORQ PUMP eliminates the gear boxes for both the high pressure pump and the low pressure boost pump. The substantial savings in money, space and weight thus effected, offer decided advantages to this compact, low-silhouette Sun test stand.

30 years of research and manufacturing experience in aircraft hydraulic components stand back of each KLINE PUMP. No other pump in the 3000-5000 psi range is so compatible with existing aircraft hydraulic systems.

In addition to Ground Support, KLINE HYDRAULIC PUMPS are designed and built for all types of industrial applications. See your local KLINE distributor or write direct for further information.

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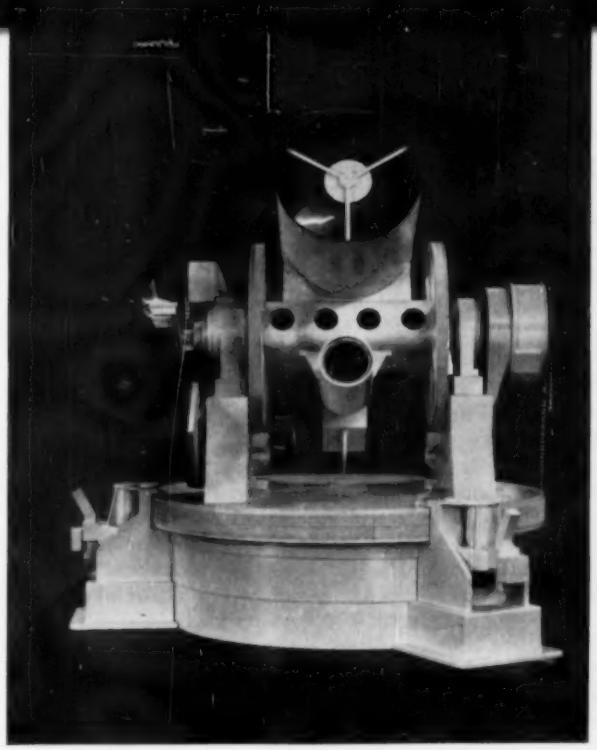
The Tracking Instrument Mount a hydraulic cable-friction servo-drive system, tracks moving targets by direct or remote control, at speeds as slow as .1 degree/sec.



Designing for slow speed tracking

• By **MARTIN KAY,** *Servo Group Leader, American Machine & Foundry Co., Greenwich, Conn.*

TO TRACK missiles, rocket sleds, or satellites, American Machine and Foundry designed for the U.S. Naval Ordnance Test Station, China Lake, Calif., a servo controlled, cable-driven instrument mount that provides the smooth, slow-speed action required for accurate tracking.

Because the tracking instrument mount uses sensitive camera-optical equipment, tracking motion at slow speeds must be smooth and vibration-free. To do this, the designers selected a combination of hydraulic valves, hydraulic motors and a multi-cable, friction drive.

The multi-cable drive reduces backlash, eliminates the clatter of conventional gear transmissions, and isolates hydraulic motor vibrations from the instrument platform. The hydraulic motors provide indefinite stall torques at low tracking speeds without the usual overrating required for electrical drives.

The hydraulic motor's open loop low smooth speed of less than 10 rpm, yields the desired speed range of

How We Synchronized Low-Speed Hydraulic Motors

When the hydraulic motors in this system operate at low speeds, they tend to develop opposing torques. This results in jerky motion. To obtain the smooth, slow movement we needed, we synchronized the motors by synchronizing their valves. Here are three problems we faced—and how we solved them.

(1) Variations of gain, hysteresis and threshold in the valves were eliminated by careful valve selection. The valves were gain matched to within 1%, with a threshold rating of .1%, and a hysteresis of about 2%.

(2) Variations of flow pressures, for small signals in the vicinity of the null region of the valves, were reduced; equal torque was maintained between the motors by connecting 1/16 ID capillary tubes between the drive motors. At one time we also considered closing a minor servo loop around each servovalve to match valve characteristics more accurately.

(3) Variations of servovalve input signals were solved by making one servo amplifier a common source to all the servovalve coils. The two coils in each valve were connected in parallel, and each set of valve coils was in turn connected in series with the servo amplifier. This equalized the input signal to each valve.

SLOW SPEED TRACKING

600:1. The hydraulic system is made up of five assemblies: power pack, azimuth drive, elevation drive, operator's chair drive, and rotary joint.

In the azimuth and elevation drive circuits, each closed center, 4-way servovalve has an output proportional to the amplitude of a common input electrical signal.

• **Power Pack**—An electrically-driven, variable-delivery pump provides system power. The 30-gpm, 2300-psi pressure-compensated pump powers the azimuth, elevation, and operator's chair drives. The system's 15-gallon sealed reservoir is pressurized to 40-65 psi for longer pump life and best performance. A thermal switch inside the reservoir monitors oil temperature and shuts-off the pump-drive motor when oil temperature exceeds 180 F. A normally open solenoid valve connects pump outlet to tank when system power is turned off. A time delay relay closes the valve after system power is turned on. This permits the pump to start under no load.

• **Azimuth Drive**—A one-piece, pre-loaded cable is wrapped 60 times around the azimuth platform, capstans, and idlers, (see illustration). Three motors drive the three capstans through individual gear boxes. Several additional wraps allow limited azimuth motion of ±720 degrees. The three capstans are equally spaced to balance the radial drive forces.

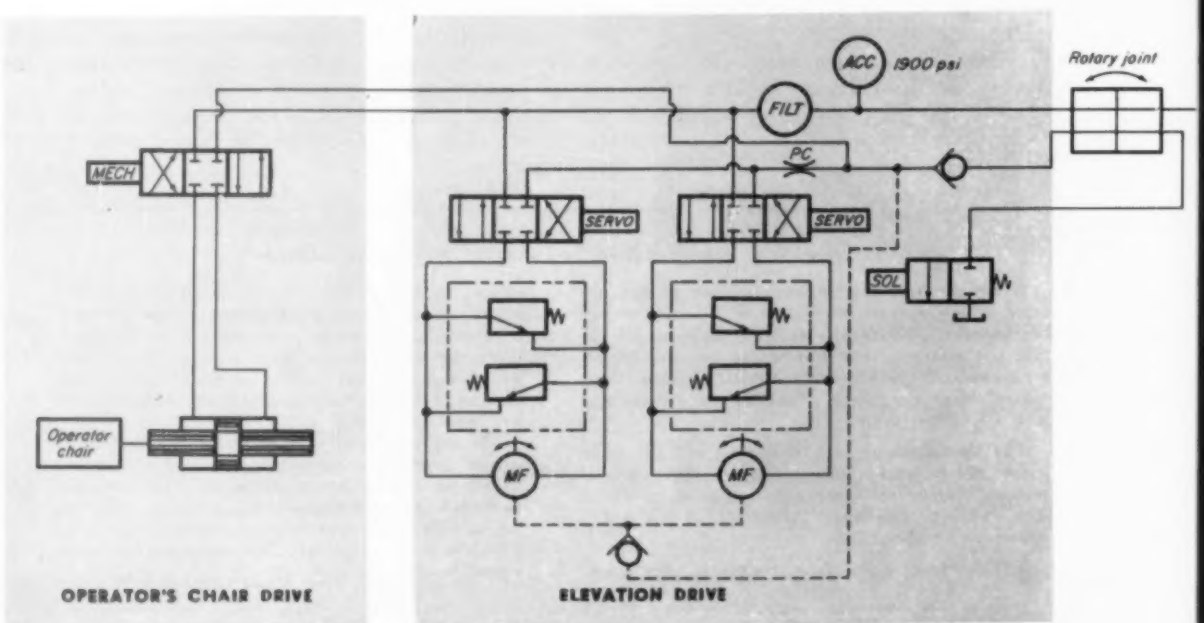
Each valve is connected to its motor with a dual relief-valve assembly manifold. These provide relief across-the-lines and keep compressed oil volume at a minimum. The motor was mounted on the manifold by removing its endcap. This makes a neat, compact package. The valves are rated at 10 gpm with a pressure differential drop of 1000 psi. The azimuth drive can develop 25 hp. A 1-gallon, 1900-psi accumulator, acts as a pressure damper and keeps oil pressure constant in the circuit.

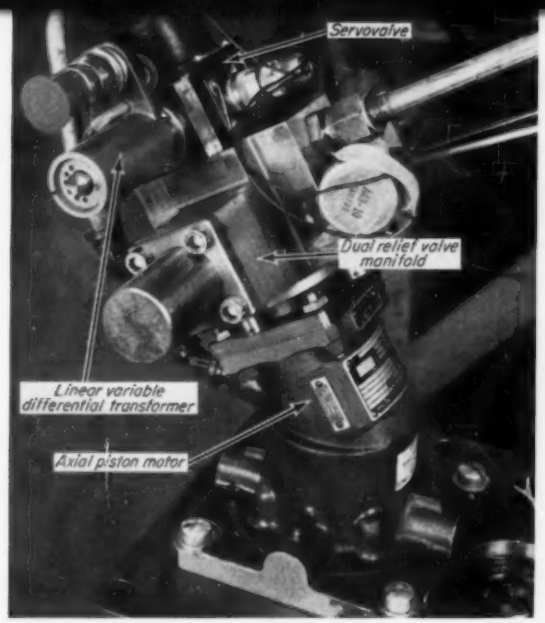
• **Elevation drive**—Each side of the elevation drive has a continuous one-piece cable wrapped 30 times around a cable wheel, capstans, and idlers. Use of gear box and a hydraulic motor on each side of the elevator platform, eliminated the torsion of instrument platforms often found on one-sided drives. The servovalves mounted on each axial-piston, fixed-displacement motor are rated at 4 gpm. The elevation drive can deliver 9 hp and has an accumulator in its circuit similar to the azimuth drive. Elevation motion is −10 to +190 degrees.

• **Operator's Chair Drive**—A mechanically actuated servovalve controls the double-acting, double rod cylinder which moves the operator's chair. The cylinder's piston is connected to a fixed frame behind the chair. As the elevation drive rotates, a cable pulls the valve spool from neutral, porting fluid to the cylinder and tilting the operator's chair. Since the servovalve housing is attached to the cylinder housing, its spool moves to neutral position, smoothly stopping the chair in the desired position. The mechanism is designed so that the operator is tilted at one-half the mount speed, and one-half the mount elevation angle.

• **Rotary Joint**—Oil is transmitted from the pump to the elevation drive through a two-way hydraulic joint. The ball-bearing mounted joint is rated at 6 gpm and 3000 psi.

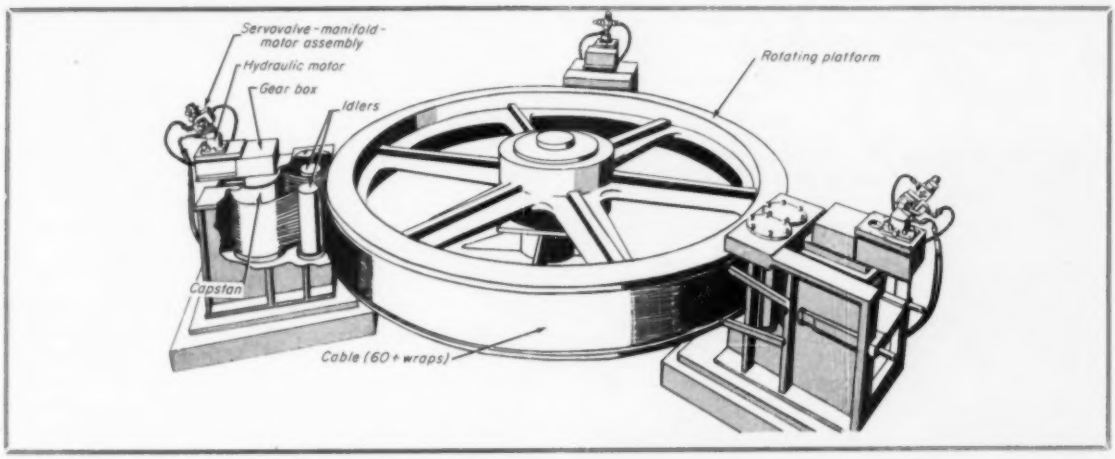
The tracking instrument mount has wide dynamic range, smooth tracking ability, and high acceleration and accuracy. The servo drive has a frequency response of 5 cps, a speed ranging from 60 to .1 degrees/second, and a maximum acceleration of 3 radians/second. ▼▼▼

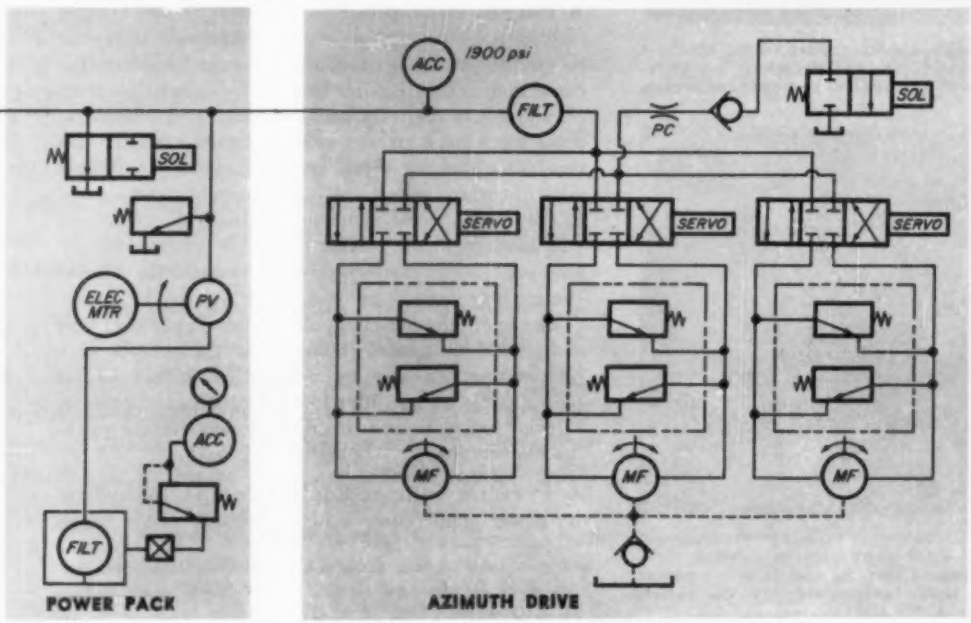




COMPACT SERVOVALVE-MOTOR combination keeps compressed oil volume small for high resonant frequency. Azimuth motor displacement is .38 cubic inches per revolution with a torque rating of 175 lb at a maximum speed of 5800 RPM. Elevation motors have a displacement of .1 cubic inches per revolution with a torque rating of 45 lb in. torque at a maximum speed of 9100 RPM.

AZIMUTH DRIVE has a rotating platform cable-driven by three equally spaced cable capstans. Three synchronized servovalve-motor units control the capstans' low speeds.

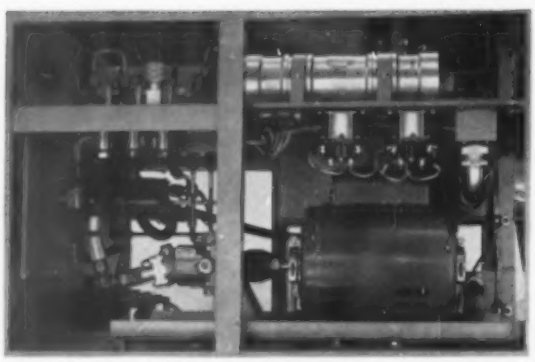




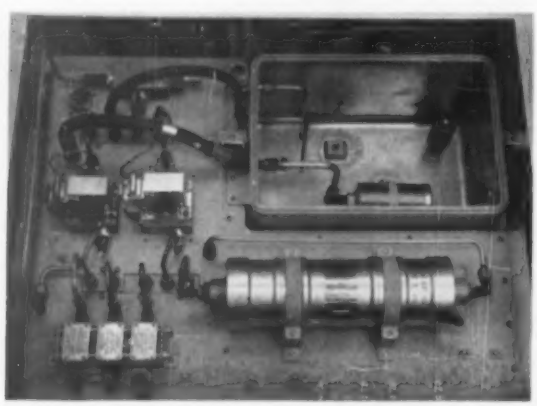
VARIABLE DELIVERY pump powers three hydraulic fixed displacement motors for the azimuth circuit and two for the elevation circuit. Operator's chair is connected to elevation circuit. A rotary joint connects the power pack, located under the azimuth rotating platform, to the motors above it.

Testing the Super Falcon

• By **GEORGE E. MILLER**, *Head of Systems Test Group Tactical Data Equipment Dept. Litton Systems, Inc.**



MOTOR-PUMP ASSEMBLY is shock-mounted on the check-out console frame. Floating nut plates, used throughout, permit replacing any component with a screwdriver and open-end wrench.



CHECK-OUT CONSOLE components (except the reservoir, pump, and motor) are mounted on an L-shaped aluminum plate. It can be installed or removed from the console as a complete unit. This simplifies production and maintenance. The console has been specially designed for easy maintenance.

THE MISSILE check-out console is the heart of the ground support system for testing the Super Falcon missile. It houses all equipment to power, test, and trouble-shoot the missile. Periodic testing is performed at tactical bases by USAF personnel using this integrated system of ground support equipment, developed and built by Hughes Aircraft. During flight, electrical and hydraulic power for the Super Falcon comes from a compact, hot-gas powered turbine, which drives an electrical generator and a hydraulic pump. Hydraulic power operates four, control surface actuators which steer the missile during flight.

• **Plug-In Hydraulic Power Supply**—The hot gas turbine is a one-shot, short life component. It cannot be used to test the hydraulic and pneumatic system because their tests are fairly lengthy. So external sources of power are used for the hydraulic and pneumatic tests. Electrical tests are only 10 sec long, so the gas turbine is used for them. Testing includes monitoring control surface deflections in response to input signals to the missile. Some signals are actual roll, pitch, and yaw motions of the missile itself. The external supply also provides hydraulic power to exercise the control surface actuators to maintain a low threshold value.

The hydraulic power supply is a small, compact unit weighing 110 lb, and is housed in the console as a plug-in unit. In case of malfunction, it can be replaced with a spare unit in two minutes, because all external hydraulic and electrical connections are quick-disconnect type.

• **Pressure Switches Control Pump**—The hydraulic power supply uses a high pressure, piston pump

**When the article was written, Mr. Miller was Head, Mechanical Unit Development Group, Guided Missile Laboratories, Hughes Aircraft Co.*

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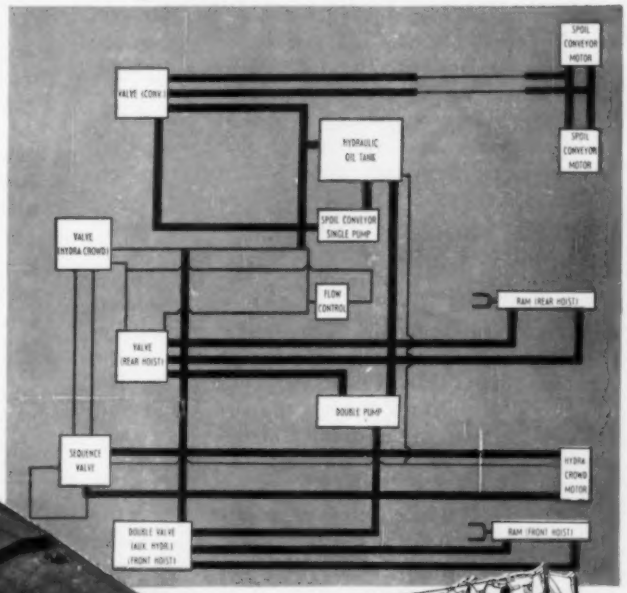
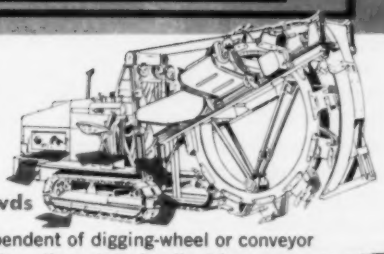


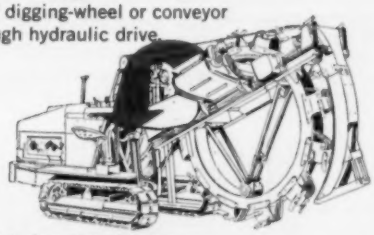
Digs

with maximum efficiency — thanks to exclusive Hydra-Crowd hydraulic transmission.



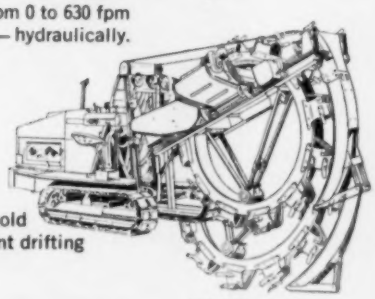
Crowds

independent of digging-wheel or conveyor speeds — through hydraulic drive.



Conveys

at variable speeds from 0 to 630 fpm with instant reverse — hydraulically.



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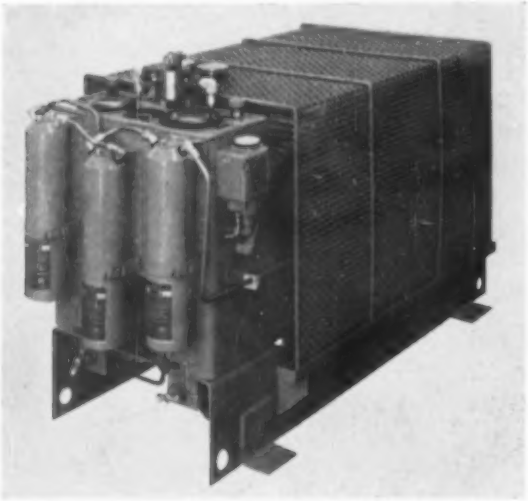
driven by a 115-volt, single phase, induction motor. The pump charges a piston accumulator to test pressure. The accumulator is precharged with dry nitrogen to 15% below minimum test pressure. When the accumulator reaches maximum test pressure, a pressure switch actuates a bypass solenoid valve, circulating fluid back to the reservoir at atmospheric pressure. A check valve maintains accumulator charge. A relief valve protects against failure of the unloading system.

• **Console Fails Safe**—When accumulator pressure drops to minimum test pressure, the pressure switch closes the bypass valve, thereby recharging the accumulator. When power is removed from the unit, both the bypass and relief valves open, reducing hydraulic pressure in the unit to a few psi. Hence, the unit fails safe in case of electrical power failure. The small residual pressure prevents the missile reservoir from inadvertently being drained of fluid before disconnecting the console's hydraulic lines from the missile.

The control surface actuators require a pressure slightly below minimum test pressure and a flow of 80% of pump capacity to unlock from their centered position. Once unlocked, demand drops to approximately 35% of pump capacity. This is due to dither and noise signals on the actuator valves and internal leakage of the actuators. During flight, the missile normally operates at a higher pressure than maximum test pressure. Testing is at a somewhat reduced pressure because *deflection*, rather than *rate* of deflection, is monitored during field test. Also, the control surfaces are not aerodynamically loaded during test.

During motion, required flow can increase to 120% of pump capacity for very short periods. Because peak flow demand of the system is of such short duration, it was more economical to use an accumulator with a pump rated at less than peak flow, rather than use a pump able to meet the peak hydraulic flow.



PNEUMATIC POWER SUPPLY is located remote from the console because it is large and heavy and it is a source of heat and noise. For quick accessibility all important controls, gages, and valves are mounted on the panel at the front of the unit.

Components of the missile hydraulic system are field replaceable, so the missile hydraulic system must be proof-tested after such maintenance. Since proof-testing is non-routine, it was decided to provide this capability in the hydraulic power supply as a manual operation. The operator raises operating pressure of the power supply by manually adjusting the pressure switch. Because it is essentially a static pressure test, the motor is overloaded for only a brief period until it charges the accumulator to the proper pressure.

• **Contamination Control**—The missile control surface system, like most servo systems, is sensitive to foreign particles in the oil. The hydraulic fluid used in the hydraulic power supply is specially processed to meet the requirements of the control surface actuators, and is shipped with the console in sealed cans. The hydraulic power supply has a fill cap strainer, a pump strainer, and one 10-micron and two 2-micron filters to insure cleanliness. Before shipment, each hydraulic power supply is cleaned and tested for cleanliness at the factory.

A liquid level gage is mounted on the front panel of the unit. A liquid level interlock in the reservoir prevents damage to the pump if fluid in the reservoir reaches a dangerously low level. When it is actuated, the interlock removes power from the pump drive motor.

• **Pneumatic Design**—The console pneumatic system consists of a pneumatic power supply, a control valve, and inter-connecting hoses and tubing. The pneumatic power supply is located remote from the console because it is relatively large and heavy compared to other subsystems of the check-out console, and because of its noise and heat. Replacement of this unit in case of a malfunction requires a fork lift truck. Because of the difficulty of replacement, a preventive maintenance program has been started to reduce compressor downtime.

The unit is made of welded steel plates with an inverted U-shaped base. Two high pressure reservoirs are on the underside of the base. It uses a 2-hp motor to drive a 2000-psi, 2.7-cfm, 2-stage compressor. Air from the compressor passes through a mechanical filter and two desiccant chambers before being stored in the high pressure reservoirs. The desiccant chambers lower the dewpoint of the air, to prevent icing when the air expands through the missile turbine nozzle.

When reservoir pressure reaches 1000 psi, the reservoir pressure switch stops the compressor motor. When reservoir pressure drops to 800 psi, the pressure switch starts the motor again.

• **Automatic Moisture Blow Down**—When the reservoir pressure switch stops the compressor motor, it actuates two solenoid valves which are connected to

Continued on page 96

Circle 134 →

CAPABILITY
is spelled
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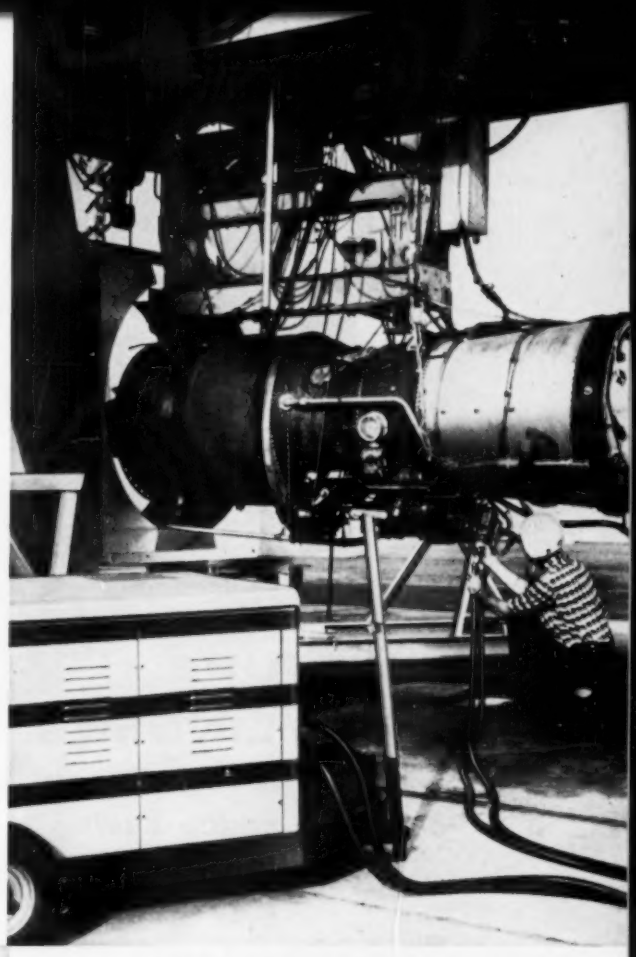
s-t-a-r-t-i-n-g

In technology and facility, Vickers continually matches your need

Auxiliary power units pioneered for aircraft turbine starting by Vickers combine high efficiency with minimum size and weight for the power delivered. Because starter characteristics are closely matched to engine requirements, they provide smooth, steady acceleration of the engine through the firepoint range giving the best possible chance of proper "lighting off" and avoiding aborted starts.

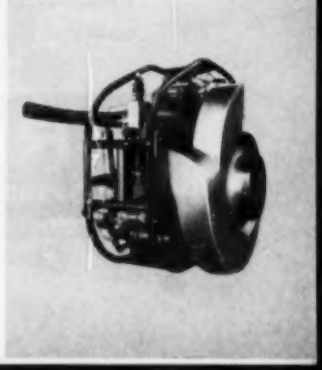
Dual-purpose units developed by Vickers as an outgrowth of pioneering work in hydraulic starting offer further benefits in weight saving. These units are used as a motor in engine starting, as a pump to supply accessory power during normal operation. Reduced cost and ground support requirements plus increased versatility and simpler remote area operation are other major benefits. Write for Bulletin A-6001.



PROVED PERFORMANCE of hydraulic starting for jet engines is demonstrated by this cart that has performed more than 2,500 trouble-free starts in a 2-year period. Cart size is due to divergent requirements of three different engines. Prime mover power requirement is only 25% of that needed for other starting methods due to inherent high efficiency of the hydraulic transmission.

JET PROP STARTING demonstration uses engine-mounted starter motor and ground cart power supply. Starter cutout speed of approximately 8,000 rpm was reached in 34.5 to 40 seconds during series of observed test starts.

MULTI-PURPOSE PUMP MOTOR (left) is pump when driving hydraulic starter becomes motor during normal flight to drive 15 KVA generator. **HELICOPTER STARTER** (right) is 35 hp unit, starts 1,900 shaft hp engine readily.



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TESTING THE SUPER FALCON

the mechanical filter and the two condenser legs which trap moisture. Opening the solenoid valves at the end of each cycle allows moisture to be automatically blown down from these moisture traps. The blow-down pressure switch closes the solenoid valves when the pressure drops to a pre-set level. The length of the blow-down period is normally 4 to 8 seconds, but it can be varied over a wide range by adjusting the blow-down metering valve, and/or the blow-down pressure switch.

Air from the high pressure reservoirs flows through a pressure regulator, set at 550 psi, to the console control valve. A flexible, braided wire, Teflon hose is used for the pneumatic interconnection. Signals from the turbine in the missile, open and close the console control valve. This admits or closes off air to the turbine, controlling its speed.

The pneumatic power supply has enough storage capacity for a normal test run and a re-test run for each missile. Recovery rate of the compressor is fast enough to rebuild full reservoir pressure while preparing the next missile for test.

• **Electrical Test With Turbine**—The hot-gas turbine is a one-shot device for generating hot gas. So it cannot be tested in normal operation. For this reason, a cold-gas test has been devised to test electrical generator output.

Air is supplied from the high pressure reservoirs through a control valve, to the turbine's inlet nozzle. The control valve is electrically connected to the same speed sensing circuit which normally regulates flow of hot-gas into the turbine to control speed. By choosing a control valve with the proper time constant, and choosing the proper air pressure, normal cycling which the turbine experiences under hot-gas operation is closely duplicated. To conserve turbine life all measurements are made within 10 seconds. Air supply is then cut off automatically. ▼▼▼

CRYOGENIC POWER

Continued from page 86

dynamic stability, which we assumed could be resolved by use of ball-screw driven motors, and materials selection, which is not too difficult.

The great advantage of this design is that it is almost perpetual. The system operates as long as propellants are available, as they must be for flight and flight control. No battery power is required. Surprisingly, the system actually benefits the propellant storage system, although its effect is relatively small. Boil-off of LH_2 in the storage bottle retards LO_2 boil-off in the propellant tank and reduces LO_2 loss. Likewise, GH_2 used by the flight control system can be returned to pressurize the LH_2 tank. These benefits are minor because the servo system is so small compared to the propellant storage system. ▼▼▼

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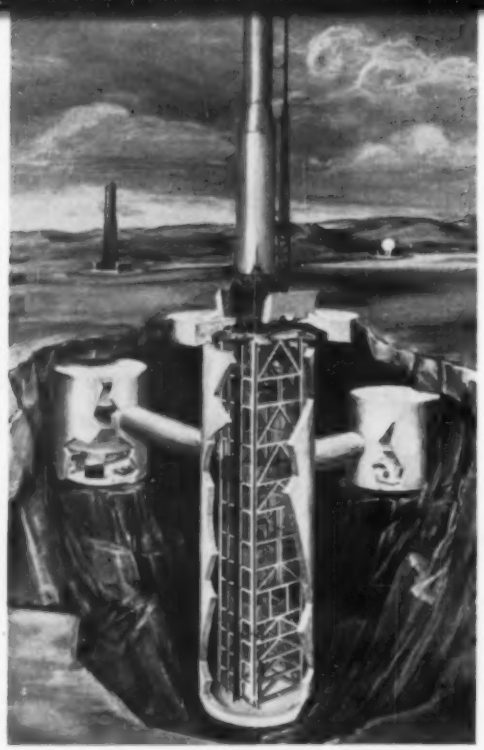

TITAN UNDERGROUND LAUNCHING SYSTEM has a hydraulically-operated launcher-erector. The missile rests on a launching platform which is raised to ground level.

HYDRAULIC FLUID EXPLODES in an oxygen atmosphere when the test weight drops onto a thin fluid film. Various hydraulic fluids were tested for LOX compatibility and fire-resistance. Water-glycol was least sensitive compared to phosphate esters and hydrocarbons.

Finding to launch

• By **MELVIN SCHECKER**

Project Supervisors Hydroneering Div., American Machine

STARTING point for designing the Titan's hydraulically-operated erection and launching system was the Air Force requirement that the hydraulic fluid be LOX-compatible—insensitive to shock, and non-explosive in the presence of liquid oxygen.

Early models of the missile will be stored in deep underground silos and will be raised hydraulically for launching. The propellant is a liquid fuel, oxidized by LOX. The Air Force was concerned that contact between hydraulic fluid and LOX might result in an explosion or fire.

American Machine & Foundry's Greenwich Engineering Division—which designed and is building the erection-launching system—specified these characteristics for their ideal fluid. They are listed in tentative order of importance:

- LOX compatibility.
- Fire resistance.
- Adequate lubricity.
- High- and low-temperature characteristics that would avoid pumping problems and excessive pressure drops.
- Compatibility with standard materials for seals, metals, and preservatives.
- Reliability—the fluid must not break down or change characteristics during storage in the system or during test cycling of the equipment.
- Reasonable cost.

• **LOX Compatibility**—The search started for a LOX-compatible fluid. AMF hired Reaction Motors and Factory Mutual to test various fluids, including hydrocarbons, phosphate esters, and water-glycols. The hope was that a suitable hydrocarbon would be found, because this would also provide the best lubricity and extreme low temperature characteristics.

Weights were dropped from various heights onto thin fluid films in the presence of LOX to determine minimum impact that would cause the fluid to explode. After a six-month's search, water-glycol base fluid proved to be the least sensitive—more than four times better than phosphate ester and six times better than hydrocarbon. It wasn't the *ideal* fluid, but it was LOX-compatible and fire-resistant; and where it fell short of the ideal, AMF's engineers were able to compensate in system design.

a fluid the Titan

and JOSEPH SCERBO,
Mechanical Sec. Greenwich Engi- & Foundry Co., Greenwich, Conn.

• **Viscosity Too High**—AMF engineers designed their system around a typical water glycol fluid as a first approach. Taking the specific gravity and viscosity at various temperatures from the manufacturer's data, they determined pressure drops throughout the system, sized piping to fit, and looked for commercial components, if available, that would give required performance.

The system was assembled and filled with the water-glycol base fluid to test its operation at extreme temperatures. There were no problems at the upper limit of 160 F. But at the lower limit of —35 F, viscosity was too high, producing excessive pressure drops. Also, starting at about —20 F, there was some separation of ice and other particles which tended to block smaller orifices.

• **Search For New Fluid**—Next, AMF contacted hydraulic fluid manufacturers, asking for a new fluid like the one which had passed the LOX test, but with lower viscosity and no tendency to form ice and other particles down to —35 F.

Meantime, designers were laying out electrical and mechan-

*

tests prove • •

unequaled reliability

**Recent tests were authorized by the Ballistics Missile Division of the Air Force, to evaluate the suitability of valves for use in propellant loading systems for Atlas Launch Sites.*

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UNSEATING TORQUE	5.8 to 11 ft. lbs.
RUNNING TORQUE	15 in. lbs. max.
MIGRATION	none

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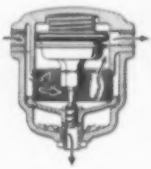
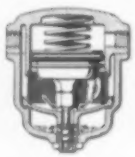


WHEN AIR IS USED,

piston automatically opens sump drain valve. No moisture accumulates, which eliminates danger of water re-entering air stream.



WHEN AIR FLOW STOPS,

moisture collected in upper chamber drops to sump—unit is then ready to drain itself.

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FINDING A FLUID

ical systems for keeping the fluid warm, in case the search for a satisfactory low-temperature fluid failed. This would make the system more complicated and expensive. Fortunately, a satisfactory fluid *was* developed, and the auxiliary warming system was not used.

The fluid was a new water-glycol formulation which was LOX-compatible, free of ice and other particle formation at —35 F, and with suitable low-temperature viscosity. However, its high temperature viscosity was lower than that of the original fluid. So AMF rechecked its pumps, selected on the basis of higher viscosity, to see what the effects would be on equipment life, and whether electrical requirements would have to be revised. Effects of the changed viscosity proved to be within allowable limits of the original system design.

• **Material Compatibility**—Now it was necessary to re-check all the components for material compatibility with the new fluid. Also, it had to be checked for compatibility with the old fluid. Because the first Titan site would not be subject to low temperatures, to save time, production had been started on the system design based on the first fluid. All components had already been tested with that fluid. If the new and old proved incompatible, it would have been necessary to disassemble, strip down, and clean all the components which had been shipped to the site, or replace them completely. This was particularly true of the seals. Fortunately, the two fluids were compatible.

Material incompatibility was minor. The new fluid tolerates a reasonable amount of contamination with non-compatible material, without losing its required characteristics. Sources of contamination are hydrocarbon preservatives in which parts had been dipped before shipping, or compounds used during lapping of close-mating surfaces. These are difficult to remove completely, so the fluid's tolerance was a big advantage.

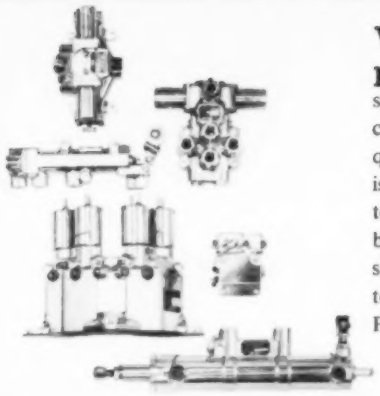
Although the new fluid causes some swelling of standard O-ring material (Buna-N) used for static seals, this is well within acceptable limits for this design.

Zinc and cadmium should not be used with the new fluid which dissolves these metals. It was not difficult to design around this.

The new fluid has less favorable lubricity characteristics than petroleum fluids. In some applications this would produce shorter life for components. But this system is designed to meet the required number of cycles with the water-glycol base fluid. Components which had passed life tests with hydro-carbon fluids had to be retested with the new fluid. In a number of cases, new models or the products of other manufacturers had to be substituted.

The Titan launcher-erector system holds about 1000 gal of hydraulic fluid. There is no external leakage, but some make-up water is needed infrequently to replace water that evaporates from the fluid. Internal leakage is about 1 gpm in the low-pressure, standby condition, and about 7 gpm during high-pressure, immediate condition. ▼▼▼

Circle 6 →



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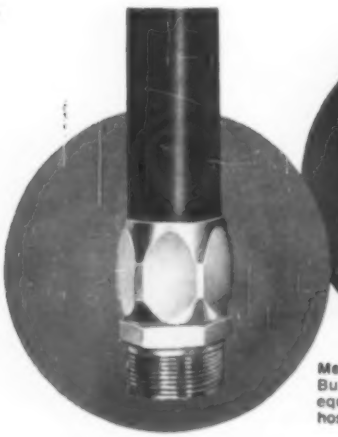
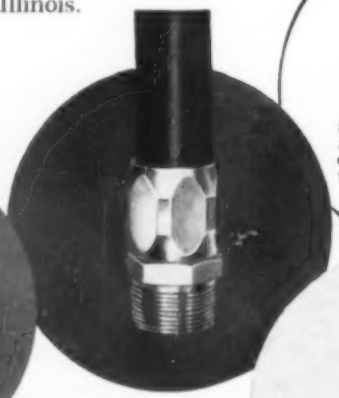
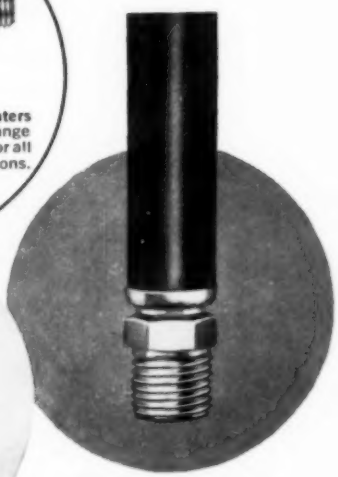


High Pressure Hose. Burst and working pressure equivalent to SAE 100R2. In hose ID's from ¼" to 2".



Medium High Pressure Hose. Burst and working pressure equivalent to SAE 100R1. In hose ID's from ⅜" to 1¼".

Medium Pressure Hose. Complies with SAE 100R3 requirements. In hose ID's from ¼" to 1".



Low Pressure Hose. Burst pressure, 1000 psi.; working pressure, 250 psi. In hose ID's from ¼" to ¾".

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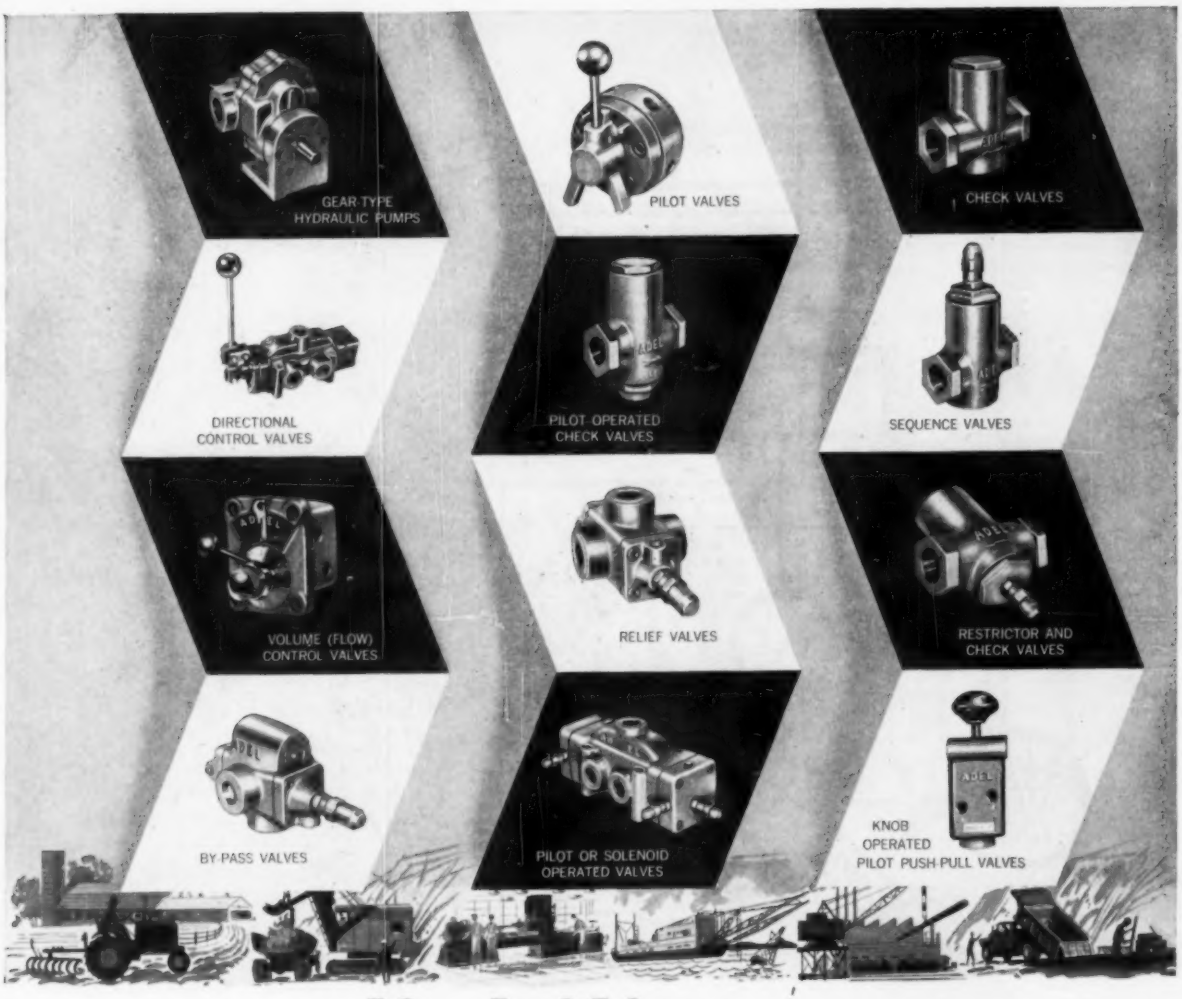

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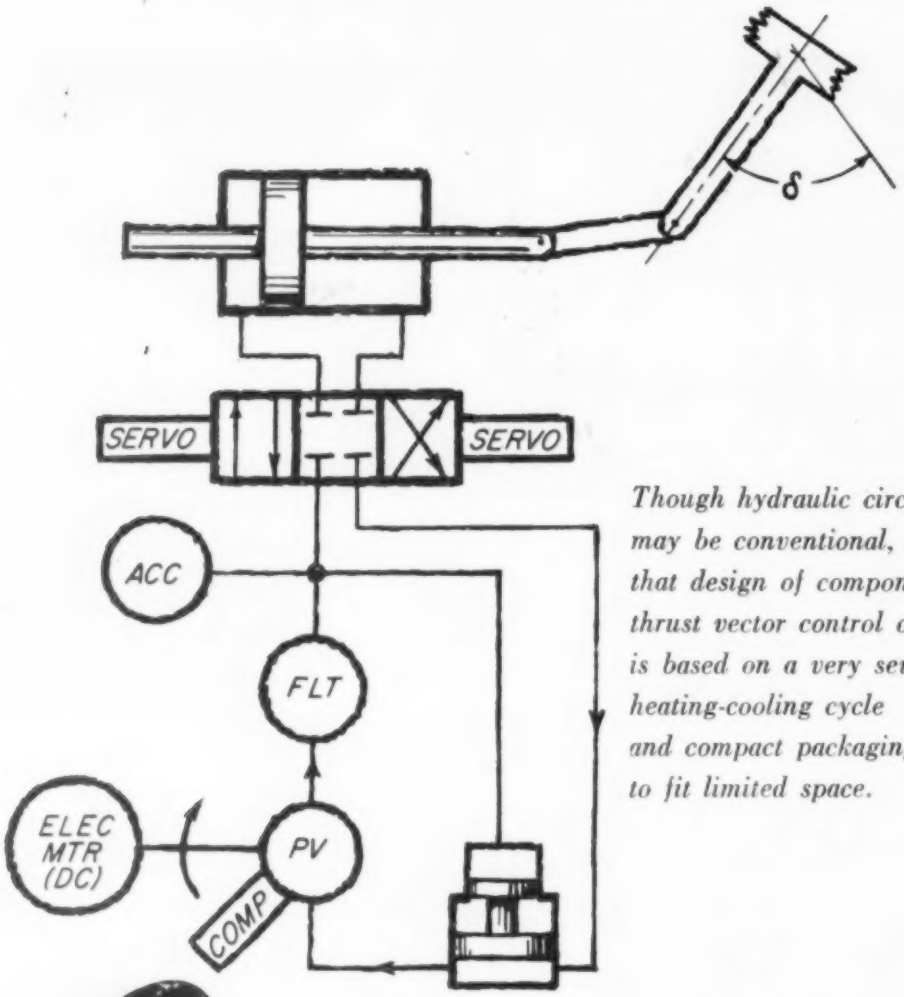

Though hydraulic circuit design may be conventional, it is evident that design of components for thrust vector control of an IRBM is based on a very severe heating-cooling cycle and compact packaging to fit limited space.

Component sizing for missile thrust vector control

• By **J. F. HECHT, SR.**, *Supervisor, and* **N. F. HARBRAUGH**, *Design Specialist, Polaris Actuation Guidance & Controls, Lockheed Aircraft Corp., Sunnyvale, Calif.*

SEVERE weight and space limitations of a missile hydraulic system, together with very short flight time and life require designing components to maximum capabilities. Little margin is left for safety as in longer-lived systems for piloted aircraft.

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In designing for light weight and compactness, component weight may be reduced to the point where dissipation of energy losses is difficult. Critical hot spots are in the pump drive motor and hydraulic fluid. The motor must have enough metal to carry heat out to the motor shell and mountings where it can be transferred to an adjoining, cooler mass. The designer of an integrated package must consider all possible means

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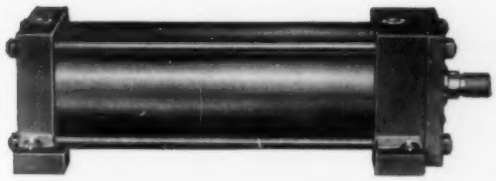

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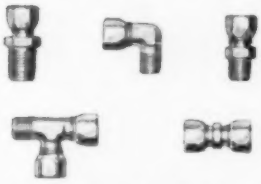

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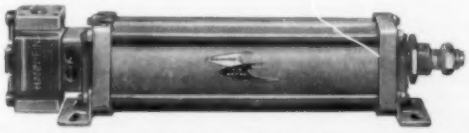

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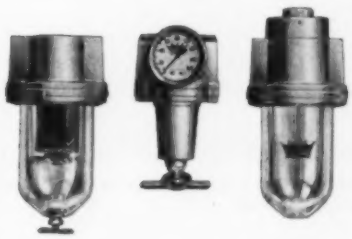

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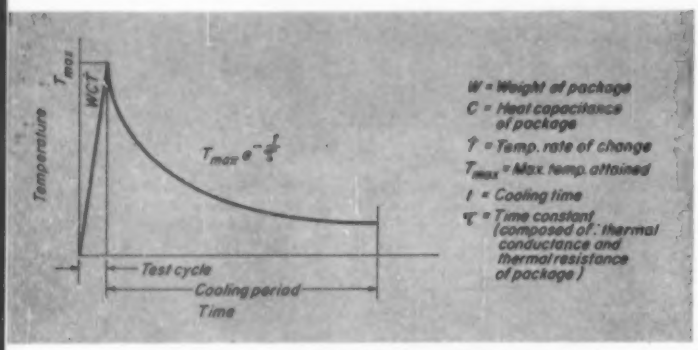


FIG. 1. OIL TEMPERATURE CHANGE in the thrust vector control system during operation and cooling.

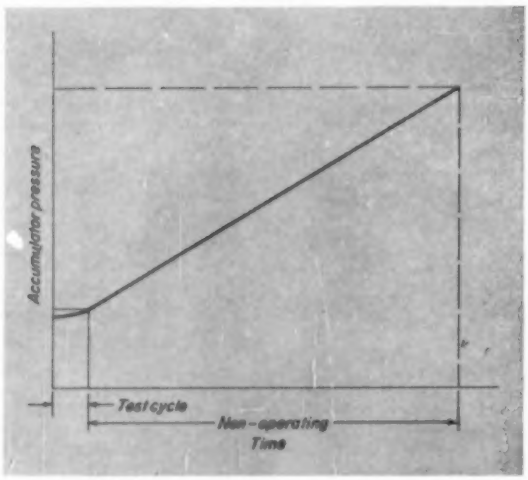


FIG. 2. TEMPERATURE EFFECT on accumulator pressure. Curve shows how accumulator pressure increases with package temperature.

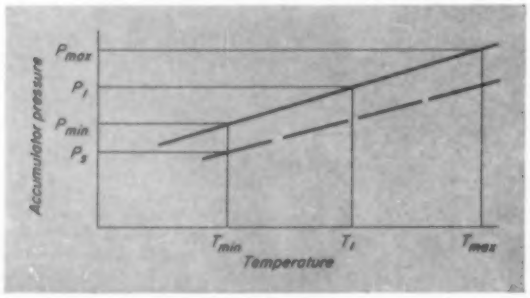


FIG. 3. ACCUMULATOR PRESSURE as a function of temperature for various precharge pressures. Lower curve is for minimum precharge pressure to produce minimum system pressure at minimum environmental temperature.

FIG. 4. ACCUMULATOR OIL CAPACITY based on accumulator precharge pressure and system pressure.

to transfer heat from the fluid to the mass of the assembly.

In this particular system, the pump-motor assembly is made as small as possible for required flow. As a result, the motor heats up rapidly. Close coupling system components makes the heat dissipation problem worse. Figure 1 shows system heating in one test cycle. Temperature rise approximates a straight line. Temperature decrease during the cooling period follows an exponential law in which the constants are a function of the particular system. Heating is rapid because there is a large power loss in a very short time. During cooling, the fluid is stagnant, and heat is dissipated slowly by conduction and natural convection only.

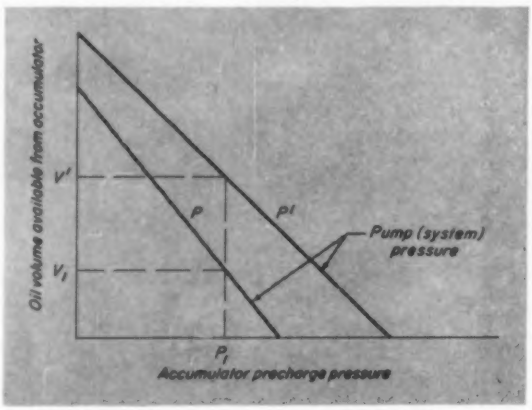
Operating life of the hydraulic system consists of checkout time as well as flight time, and the number and frequency of checkout periods is a major consideration. Checkout periods must be followed by cooling periods long enough to keep motor and fluid temperatures within safe limits. The hydraulic system package is covered by insulation to protect it from external heating during flight. This insulation further decreases the cooling rate.

• **Accumulator Sizing**—During normal flight conditions, the pump supplies sufficient fluid for average vector control demands. Accumulator size must be based on the peak flow demand. A pump large enough to supply this peak rate would operate during most of the flight at such a low efficiency as to severely penalize system weight by increasing the input power requirement. The larger, heavier pump-motor would further increase space and weight.

Oil heating produces a pressure increase in the accumulator as the temperature of the package increases. This pressure increase is delayed by the time required for the heated oil to warm up the mass of metal in the package, and in turn to warm up the gas in the accumulator, as shown in Figure 2.

Effects of pre-launch operation for system checkout, resulting in package temperature increase, greatly affect accumulator sizing. Heating caused by a checkout test must be known in order to design the accumulator to minimum volume.

Accumulator precharge pressure changes with temperature. The higher the temperature, the higher the



resulting pressure in the accumulator, and the less oil the accumulator can hold. Therefore, gas temperature in the accumulator at the time of missile firing determines the available volume of oil stored in the accumulator. This volume must be adequate to supply peak flow demand at a pressure high enough to overcome the load.

• **Ambient Effects**—Environmental temperature range of the missile is equally as important as the heating caused by checkout. Accumulator precharge pressure must be based on ambient temperature at the time of pressurization. If ambient temperature is high, then precharge must be high so that accumulator pressure will not be too low when ambient temperature drops to its minimum value. The relationship between accumulator pressure at various temperatures when initially precharged to a given pressure is shown in Figure 3. A family of curves could be drawn to show the relationship between accumulator pressure and ambient temperature for various initial precharge pressures. If accumulator precharge pressure is set at P_1 at temperature T_1, then accumulator pressure is P_{max} when the package is stabilized at maximum environmental temperature T_{max}. At minimum environmental temperature, T_{min}, accumulator pressure is P_{min}. Corresponding pressures, under similar stabilized temperature conditions, with other initial precharge conditions can be determined in the same way.

Since torque is directly proportional to system pressure, a minimum accumulator precharge pressure must correspond with minimum torque required of the system. System pressure must never fall below a minimum, and this limits accumulator discharge. The pump can deliver a certain maximum flow. If the error signal to the servovalve demands a higher flow, additional fluid must come from the accumulator. Therefore accumulator size depends on how much additional flow is required and for how long. Figure 4 shows the relationship between accumulator delivery and precharge pressure. A family of such curves can be drawn each representing accumulator capacity as a function of precharge pressure for a particular system pressure.

For example: if initial precharge was P_1 and the system pressure was P during pump operation, oil volume which would be stored in the accumulator would be V_1. If system pressure had been higher, as P_1, then oil volume would be V. The curves approximate straight lines for small changes in pressure.

• **Servovalve Sizing**—The servovalve is sized to handle peak flow rate with minimum pressure drop consistent with the gain range for system stability. This gain range is the ratio of flow at zero load to flow at rated load for a given valve current or spool position. Minimum pressure drop across the valve means minimum power loss and heating at this point.

The servovalve is a 2-stage flapper-nozzle, flow control type. Internal leakage consisting of first stage nozzle flow and leakage past the second stage spool lands is important because it requires additional pump capacity, represents power loss and heating, and influences contamination susceptibility of the system. In a system as small as this one, servovalve leakage is

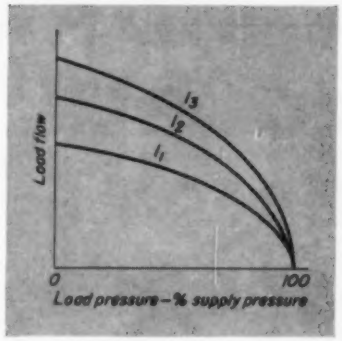


FIG. 5. SERVOVALVE ORIFICE CHARACTERISTICS show flow as load pressure increases to supply pressure.

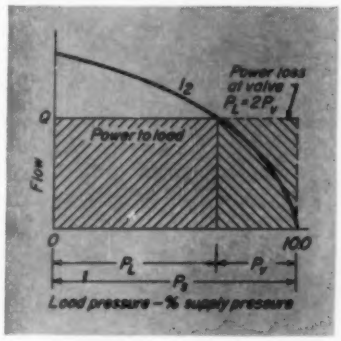


FIG. 6. POWER TRANSFERRED TO A LOAD through a servovalve is maximum when differential load pressure is twice valve pressure drop.

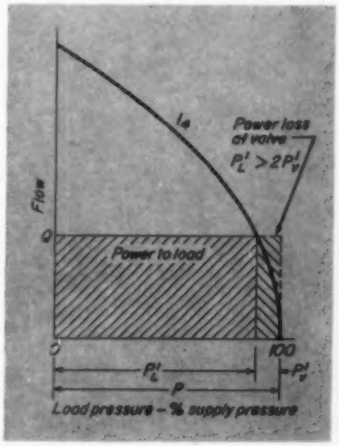


FIG. 7. INCREASING SERVOVALVE GAIN by increasing flow as a function of input current reduces power loss at the valve for a required load flow. Gain must not be increased high enough to make the system unstable.

especially critical, because it is such a large part of pump capacity that it becomes a major factor in influencing weight and size of the system package and storage battery supplying the pump drive motor.

The relationship between servovalve supply pressure and flow to the actuator is shown in Figure 5. This is a family of parabolic curves typical of 2-stage flow control valves.

Each curve is the flow-pressure characteristic of the particular orifice uncovered by the valve spool as it moves in response to valve command current (I_1, I_2, or I_3). For a fixed load pressure, flow is proportional to

Continued on page 108

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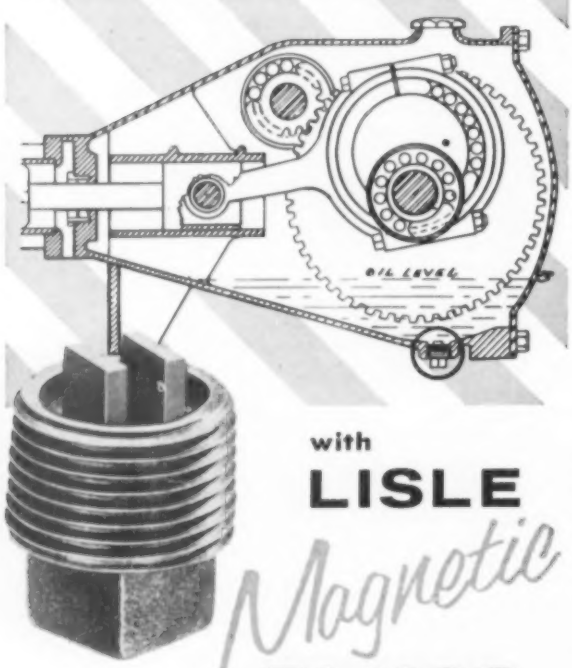

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valve current. For most valves there is a maximum saturation current, where a further increase in input signal does not produce a corresponding incremental increase in valve output.

• **Maximum Power**—A flow control servovalve delivers maximum power to the load when the pressure drop across the valve is one-half of the pressure across the load. This is illustrated in Figure 6. By changing the valve's flow-pressure characteristic it is possible to transmit the same useful power and reduce power loss. A large gain change means that maximum pressure available to the actuator approaches system pressure and that valve pressure drop and power loss at maximum load are small. This is illustrated in Figure 7.

It is frequently advantageous to deviate from the accepted standard ratio of load pressure drop equal to twice the valve pressure drop in order to use a valve with minimum pressure drop, keeping in mind that gain must not go high enough to make the system unstable. In other words, the servovalve should be "oversize" for a lower internal pressure drop. Increasing valve capacity for increased flow does not necessarily mean increasing size or weight.

System stability is a function of the servovalve gain, so it is not practical to increase slope of the flow-pressure curve until pressure drop across the valve disappears. System gain is proportional to flow, and therefore proportional to load pressure drop. In sizing a servovalve, possible gain change due to load variation must be considered in terms of system stability. For a good design, it is necessary to make an equitable trade between system stability and pressure drop across the valve.

• **Actuator Sizing**—When maximum actuator differential pressure has been selected to meet a specified output load requirement, the actuator swept volume is determined. Selecting the actuator area and stroke to give this volume usually depends upon:

- Space available for a cylinder (length and diameter)
- Optimum linkage for transmitting thrust to the load
- Selection of lever arms for minimizing effects of backlash and bearing friction
- Permissible variations in ratio of load angular travel to actuator linear travel and load torque to actuator thrust for a rotary load.

• **Reservoir Design**—A bootstrap reservoir is incorporated in this hydraulic package. Fluid in the return of low pressure side of the system is pressurized by a differential area piston having its smaller face exposed to the high pressure fluid in the system. In addition to being a storage space for hydraulic fluid, the reservoir therefore provides a positive pressure at the pump inlet to prevent cavitation. The first revolution of the pump builds up sufficient pressure, through the differential piston, to pressurize the pump inlet. Reservoir volume must be adequate to fill the accumulator and make up any external leakage. ▼▼▼

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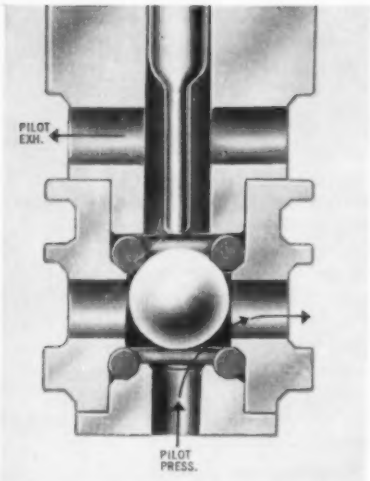

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To Achieve Endurance, a Breakthrough in Speed

Generally, the most unpredictable factor in solenoid valve life is the solenoid coil itself, and yet, a solenoid can be made to last practically forever if the coil can be kept from overheating. Coil heat is generated by long plunger travel and accelerated by erratic drag (friction) during that travel. Achieve a short, quick, sure plunger stroke and the coil will last indefinitely. Therefore, the life of a solenoid pilot air valve is directly related to speed of operation. To achieve operating speed, friction in the pilot section and solenoid plunger travel must be reduced to a minimum. Solve these problems and you get air control reliability that seems to have no limit.

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To control the major source of coil burnout, coil heating, the stroke of the solenoid plunger must be reduced to a minimum. The short stroke fractions the time the coil is energized; heat generation drops and response time of the valve is stepped up. In the "Mach 2" the stroke has been reduced to 3/32 — about the thickness of a nickel. Furthermore, the friction problem must be solved, to avoid any unpredictable drag. In the "Mach 2" this has been done by use of a pilot cartridge enclosing a free-moving ball that seats on "O" rings at both ends of the cartridge [see above]. The ball moves freely, independent of the seals. There is no "O" ring drag on the pilot plunger as it requires no seals. When there is no friction there is no wear. Similarly, the main valve seats seal on "O" rings. In the sealed position, metal shoulders take the shock in such a way that the "O" ring seal is merely kissed by the main valve seat [see (5) below]. As the rings are only minutely flexed they do not fatigue or lose their resilience.

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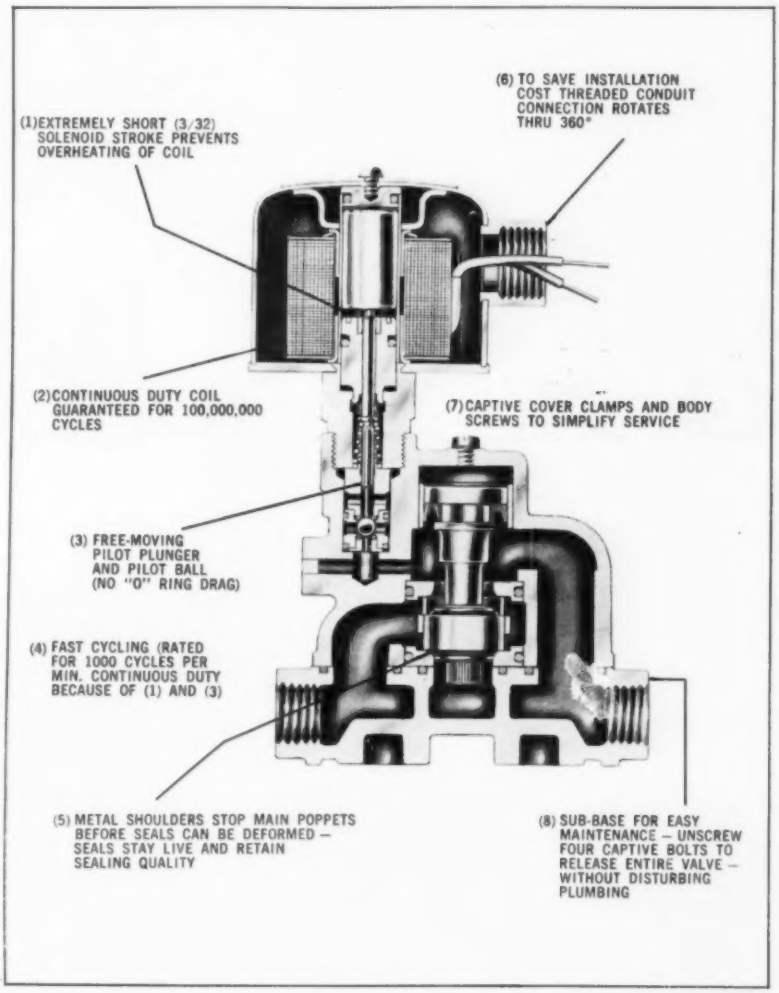
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for Hydraulic-Pneumatic Service

For top efficiency and little downtime, apply Garlock Teflon Packings wherever fluid power is used.

CHEVRON†Packings of solid Teflon—or rubber, coated with Teflon—are as close to "frictionless" as you'll find. First of all, Teflon has the lowest coefficient of friction of any solid material in use today. Moreover, the CHEVRON itself is designed to permit free operation with minimum friction at all pressures. Here's how: with increasing pressures, CHEVRON packing rings tighten to prevent leakage. As pressures decline, the rings instantly ease off, permitting free operation of the rod, ram, or piston without leakage. This exclusive hinge-like construction lengthens packing life and, with proper initial adjustment of the gland, eliminates all further adjustments necessary to compensate for pressure variations. Catalog AD-115.

Teflon "V" Rings for higher pressures. Flexible enough to respond quickly to low gland and fluid pressures due to tapered "V" design.

"O" Ring Packings made of solid Teflon or rubber, coated with Teflon provide exceptional anti-friction qualities on equipment where a round-bodied seal is required. And, a new slotted Teflon ring is available to simplify installation in standard AN grooves. Catalog AD-148.

Teflon-Coated Cups—the first advance in cup design in thirty years. Garlock has perfected a technique whereby cups are coated with a thin layer of Teflon which then becomes an integral part of the cup. Teflon-coated cups reduce breakaway and running friction, and completely eliminate "squealing." Catalog AD-145.

GARLOCK

Other fine advantages of Teflon packings: Solid Teflon is chemically inert, non-flammable, resilient, long wearing. It can be applied against new synthetic hydraulic fluids at temperatures ranging from −100°F to +500°F.

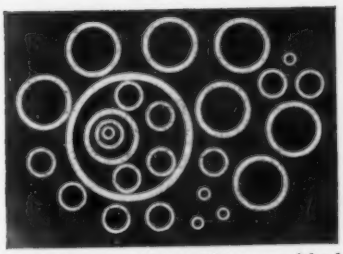
Discuss Garlock Teflon Packings with your local Garlock representative. Call him at the nearest of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada, or write Garlock Inc., Palmyra, N. Y.

Canadian Div.: Garlock of Canada Ltd.

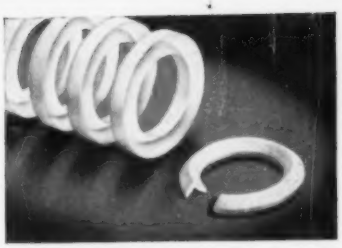
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

†Registered Trademark *DuPont Trademark

Circle **142** on Reader-Service Card



"O" Rings are applied where round-body static or dynamic seals are required



"V" Rings are used as piston or stuffing box seals against reciprocating and oscillating motions

CHEVRON Packings assure positive seal on rams, plungers, reciprocating rods

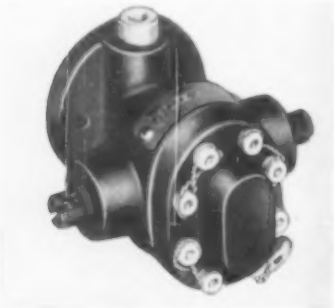
Teflon-coated cups reduce breakaway friction on inside-packed reciprocating pistons

AEROSPACE COMPONENT DATA

Pump-Motor Combination

Features: High speed gear pump driven by d-c motor for raising or lowering skis or wheels on bush planes.

Specifications: Pump handles 0.4 gpm (imperial) at 1500 psi. It is



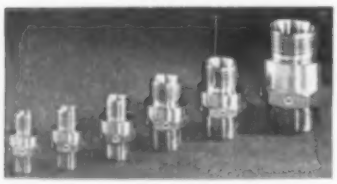
driven by a 24/28-vdc motor and meets military specifications. Fluid is MIL-O-5606 oil.

Designation: Model 1732 HBV 253 B.—*Eastern Industries, Inc., Hamden, Conn.*

Circle **500** on Reader-Service Card

Miniature Check Valves

Features: For high pressure hydraulic applications, saves weight and space. Stainless steel is standard material, but can be furnished in other materials. Can be supplied in a variety of configurations.



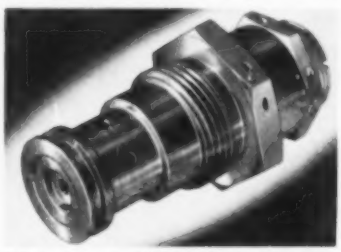
Specifications: Made in ¼" through 1" OD sizes with flared or flareless tube fitting ends. 3000-psi operating pressure, with zero leakage. Cracking pressure: 2 to 8 psi. Internal leakage: zero at 1000 psi, 3 cc/hr at 5 psi. Temperature range: −65 to 450 F. Flow ranges from 1.2 gpm for ¼" size to 29.0 gpm for 1", with pressure drops well below 15 psi. ¼" OD size with flareless tube fitting ends is 1.344" long, weighs 0.062 lb. 1" OD size is 2.438" long and weighs 0.512 lb.—*The Weatherhead Co. Special Products Div., Cleveland, O.*

Circle **501** on Reader-Service Card

Cartridge Flow Regulator

Features: Regulator maintains constant flow to the system when pump output or upstream or downstream pressures vary. Use in a single body or a multi-valve manifold. Regulator is made from hard-coated aluminum and passivated stainless steel.

Specifications: Regulator is rated to 2000 psi and has a 25-psi to 50-psi pressure drop. Weighs 4 oz.



While the regulated flow is factory set, the regulator has an external screw for up to ±10% field adjustment of flow. Is available in 0.1-gpm to 6.5-gpm flows.—*Fluid Regulators Corp., Painseville, Ohio.*

Circle **502** on Reader-Service Card

Fast Response Check Valve

Features: Positive sealing, check valve for use with hydraulic fluids, inert gases, hydrogen peroxide, etc. Various seats depending upon fluid.

Specifications: Overall length is 2.280", 0.812" diameter, and 1.2 oz weight. Standard model to 3000 psi pressure, with others to 4500 psi. All models operate at −65 F to

160 F. Male ports meet AND 10056-4 and are for connection with ¼" tubing or hose.

Designation: CVM4C.—*Marotta Valve Corp., Boonton, N.J.*

Circle **503** on Reader-Service Card

Facts On Fluorosilicone Rubber

Brochure contains information on Silastic LS fluorosilicone rubber. Graphs show the tensile, durometer, elongation, volume change of Silastic LS during oven aging and ASTM oil exposure tests. Typical properties and practical tables suggest when to design with Silastic LS.—*Dow Corning Corp., Midland, Mich.*

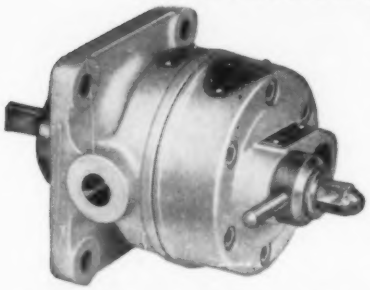
Circle **504** on Reader-Service Card

Pressure Transducers

Booklet describes variable reluctance pressure transducers which use a single moving part. A metal diaphragm, whose center moves only a few thousandths of an inch over the full pressure range, in an electromagnetic circuit senses absolute, gage, or differential pressures

Continued on page 114

Circle **119** on Reader-Service Card



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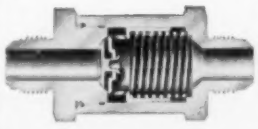
Circle **32** on Reader-Service Card

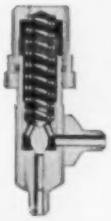
ground support and test equipment

REPUBLIC VALVES



FREE-FLOW CHECK VALVES
No leakage. 3000 psi. Very low pressure drop. Can be furnished to open at ¼ to 35 psi. Brass, stainless steel, or aluminum alloy. ⅛" to 2" pipe or tube. Temp. range -65° to 200°F.

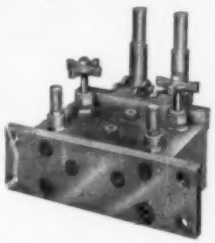
RELIEF VALVES
Quick unloading, smooth operation. Guided shut-off piston with stainless steel or Nylon seat. Pressure range to 4000 psi. Brass, aluminum alloy, or stainless steel. ¼" to ¾" pipe or tube. Temp. range to 400°F.



HAND PUMP
For hydraulic applications on missile carrier and support equipment. Double-acting. 2 cu. in. displacement per cycle. 1000 psi. working pressure. Aluminum alloy body, stainless steel trim. -65° to 160°F.

LEVELATOR VALVE
For automatically maintaining height and level condition in any vehicle with air spring suspension. Controls swaying in transit, and off-level position while standing. Applicable to trucks, buses, trailers, carriers, cranes, etc.

LO-TORQ SELECTOR VALVES
Smooth, easy operation, with low turning torque because of pressure balancing design. 0 to 6000 psi. Bronze, steel, or aluminum alloy. ⅛" to 2" pipe or tube. 2, 3, 4 ports.



DUAL HAND PUMP
2 pumps, 2 relief valves, and 2 needle shut-off valves, compactly manifolded for elevating mechanisms, hydraulic applications on ground support equipment, etc. Aluminum alloy body, stainless steel trim. -65° to 160°F.

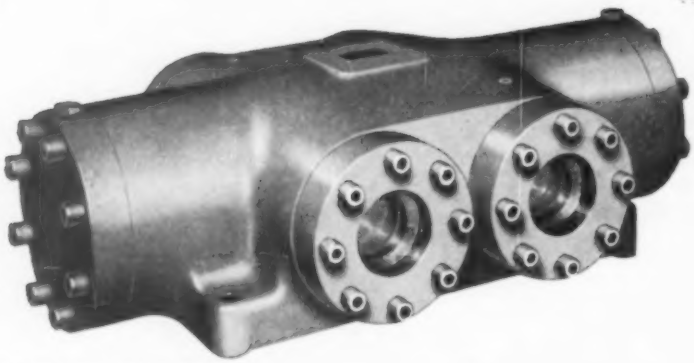
Distributors in principal cities coast to coast

CHECK RELIEF SELECTOR GLOBE NEEDLE PLUG

RM **REPUBLIC MANUFACTURING CO.**
15655 BROOKPARK ROAD • CLEVELAND 35, OHIO

Circle **82** on Reader-Service Card

GROUND SUPPORT HYDRAULICS



H-P-M 4-Way Valve; 3000 psi, 450 gpm, pilot operated, flange connections.

H-P-M 4" Angle Check Valve; 3000 psi, flange connections.

H-P-M 3-Way Valve; 3000 psi, 350 gpm, pilot operated, flange connections.

H-P-M valves, such as those illustrated, are used on Titan ground support installations. Moving large volumes of oil at high pressures for today's missile installations parallels H-P-M's experience in the heavy machinery field. H-P-M's reputation for dependability and performance in this field is unmatched, has a complete line of hydraulic equipment for both large and small systems. Write for our latest catalog.

H125

THE HYDRAULIC PRESS MFG. COMPANY
A Division of Koehring Company, Mount Gilead, Ohio, U.S.A.
Circle **60** on Reader-Service Card

AEROSPACE COMPONENT DATA

in ranges from 0 to 0.1 through 0 to 5000 psi. Included are single and dual coil transducers and complete pressure-to-voltage systems for d-c applications. All can be used with dirty or corrosive fluid.—*Ultradyne, Inc., Albuquerque, N. M.*

Circle **505** on Reader-Service Card

Rubber-to-Metal Seals

Features: Rubber-to-metal bonded seals of this new formulation of a basic butyl elastomer shows superior swell resistance to Skydrol, fire-resistant hydraulic fluid. New compound and bonding process produce permanent, effective seals in fire-resistant hydraulic systems.

Designation: Permatized bonding using Compound SH 617-75.—*Stillman Rubber Co., Culver City, Calif.*

Circle **506** on Reader-Service Card

Gas Dehydrator

Features: Continuous-duty dehydrator dries air or gas to −180° dewpoint. Dehydrator cycles only as required for maintaining flow of dry gas. This is an advantage when expensive gases are used. Dehydrator also filters, no servicing of desiccant.

Specifications: Provides up to 25 scfm of air with 1/10th ppm water vapor. 115 vac, 60 cycle.

Designation: Lear-Air Dry Gas Pak —*Lear, Inc., Industrial Products, Grand Rapids, Mich.*

Circle **507** on Reader-Service Card

Pump, Compressor Drives

Features: Direct current motors for hydraulic pump, pneumatic compressor, and other drives are described in Bulletin #1400. Some

Continued on page 116

Circle **54** on Reader-Service Card

For long-lived high performance, get

GAST ROTARY AIR PUMPS

Here's the broad Gast Line of Air Compressors. Vacuum Pumps, too, are made in all these models. Capacities from .6 to 45 cfm., pressures to 30 psi., vacuum to 28" Hg. Rotary-vane design is simple, efficient, dependable. Positive, pulseless air delivery—no tank needed. For plant use or O.E.M., *get Gast quality!*

Write for Gast Catalog; describe your specific needs.

GAST MANUFACTURING CORP.
P. O. Box 117-D, Benton Harbor, Michigan

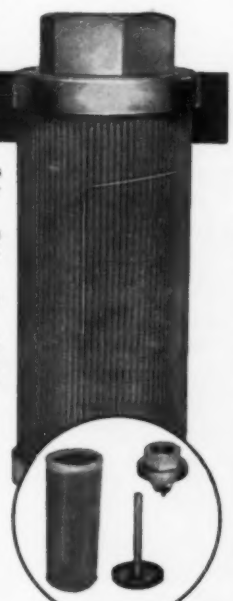
See Catalog in Sweet's Design File

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Capital HYDRAULIC FILTERS



STANDARD RESERVOIR TYPE — 7 sizes . . . 5 to 50 gallon capacity and larger sizes on special order.

MONO-BILT — Standard, All Stainless Steel in 7 sizes . . . 5 to 50 gallon capacity and larger sizes on special order.

MONO-BILT — 60 Mesh Sump Type in 7 sizes . . . 5 to 125 gallon capacity.

MONO-ECONO — Specially Mono-Bilt with Monel Metal Insert . . . Cadmium plated top and bottom. 9 sizes . . . 5 to 150 gallon capacity.

MONEL METAL INSERTS

Line Type HYDRAULIC FILTER

3 sizes . . . 5 gallon, 8 gallon and 10 gallon capacity.

Send for descriptive circulars

CAPITAL ENGINEERING & MFG. CORP.

5837 South Ashland Avenue, Chicago 36, Illinois

Circle **30** on Reader-Service Card

H·I·S PRECISION TEFLON* "U" Cups FOR LOW FRICTION----- ---HIGH TEMPERATURE in any hydraulic fluid

Style 4505 "U" cups are accurately machined of virgin TEFLON to a special design developed by HALOGEN. 246 standard sizes are available without tooling charges.

Also available:

HALOGEN "V" RINGS

two types available for packed cylinders and other applications.

Write for literature . . . our new 12 page brochure on "U" cups is yours for the asking.

*DuPont T.M.

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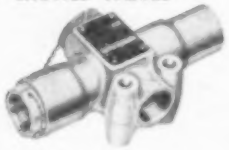
"Engineers and manufacturers— TEFLON Products"*

Circle **61** on Reader-Service Card

RELIABILITY
AND
PERFORMANCE
are our main products

First, imaginative design; then experienced thoroughness through development, tooling, production, assembly and tests, all under strict quality control in an unusually well equipped plant . . . we can help you solve your special problems . . .

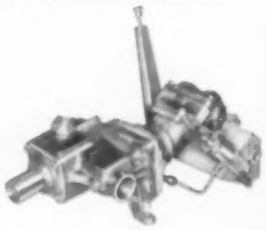
- SHUTTLE VALVES



- RELIEF VALVES

- SELECTOR VALVES

- COMPLEX PACKAGES



also

- SOLENOID VALVES
- TRANSFER VALVES
- BRAKE VALVES
- PRESSURE REDUCERS
- FUEL PUMPS
- DEHYDRATORS
- COMPACT COMPRESSORS

WRITE, wire, or phone for data, quotations and service.

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LAKE ORION, MICHIGAN
PHONE: MYRTLE 2-2711

Circle **85** on Reader-Service Card

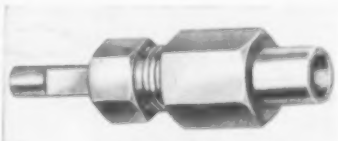
AEROSPACE COMPONENT DATA

types of motors are: fluid cooled, higher temperature (600 F and above), explosion-proof, submersible, and gearhead. Features of each motor are given together with suggested applications. Specifications such as horsepower, voltage, size, and weight are also given.—*Hoover Electric Co., Los Angeles, Calif.*

Circle **508** on Reader-Service Card

Ultra-High Vacuum Couplings

Features: No leaks are detectable on a helium mass spectrometer with



a sensitivity 1.7 x 10^{-10} atmos. cc/sec/division. Reassembles simply. All metal design permits operation at elevated temperatures. Available in sizes for ¼" through ⅝" tubing.—*Cajon Machine Co., Cleveland.*

Circle **509** on Reader-Service Card

Miniature Pressure Transducer

Features: High output pressure transducer for telemetry and control applications in missiles. Entire mechanism, including the potentiometer element, is hermetically sealed in a stainless steel case.

Specifications: All effects of linearity, hysteresis, resolution, friction,

repeatability, and interchangeability are within a static accuracy band of ±1.5%. Time constant is less than 2 millisec. Temperature sensitivity is less than 0.005%/degree F over an operating range of −150 F to 225F. Counterbalanced mechanism permits operation under vibration of 25g to 2000 cps. Unit is less than 1" in diameter and 2" long and weighs 3¾ oz including pressure and electrical connections. Standard units are available in 8 ranges from 0 to 5000 psi. Output to 75 v.

Designation: P104 series.—*Trans-Sonics, Inc., Burlington, Mass.*

Circle **510** on Reader-Service Card

Elastomeric Compound

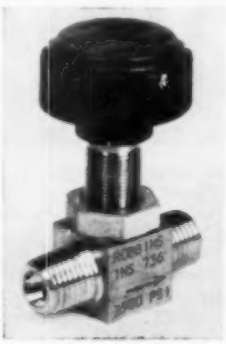
Features: For O-rings, seals, and packings for precision instruments and systems containing fluourocarbon fluids and lubricants, and helium. Accelerated service tests indicate service integrity greater than 5 years. O-rings are suited for inertial guidance equipment. O-rings are molded in chrome-plated tooling to prevent contamination.

Designation: FR6-60-13—*Fargo Rubber Corp., Los Angeles, Calif.*

Circle **511** on Reader-Service Card

Miniature Metering Valve

Features: Small, metering, globe valve with male ports is for use with gases and liquids such as hydraulic oils, water, and fuels.



Specifications: Valve body is ¾" x ¾" x 1¾". Valve is 2¾" high fully opened. Operating torque is 4 in.-lb. at 2500 psi. Operating pressures from high vacuum to 3500 psi. Weight is 0.31 lb.

Designation: INS736.—*Robbins Aviation, Inc., Los Angeles, Calif.*

Circle **512** on Reader-Service Card

Helium Regulator

Features: Helium regulator controls missile fuel tank pressure. Two-stage design reduces effect of large flow ranges and variations in temperature and inlet pressure. Usual balancing devices requiring dynamic seals are

omitted. Instead static and poppet seals and synthetic material diaphragms are used. Each seal is Teflon seated. Diaphragms are protected from over pressure by an

interstage relief valve. Changing diaphragm material allows valve to accept a variety of gases or fluids.

Designation: No. 434101—*Dyna-Matics Corporation, Sun Valley, Calif.*

Circle **513** on Reader-Service Card

Electrohydraulic Servovalve

Features: Ultra high response servovalve controls a hydraulically tuneable magnetron tube requiring a closed loop amplitude response of +2 db from 0 to 100 cps with full amplitude of 0.15 in. and a static positional accuracy of ±0.0015.

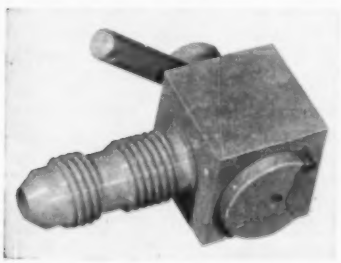
Specifications: Operating pressure is 600 psi. Rated no-load flow is 1 gpm. 2-coil, 4-wire configuration. Weight is 0.9 lb. Size, about 3" x 2¼" x 1⅞".

Designation: UHR.—*Dalmo Victor Co., Division of Textron, Inc., Belmont, Calif.*

Circle **514** on Reader-Service Card

High-Pressure Bleed Valve

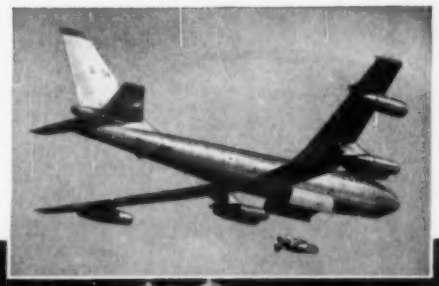
Features: Valve blows down or bleeds off high pressure gas or hydraulic systems. Easy manual actuation. Five in.-lb. torque fully opens or closes valve in a quarter turn at

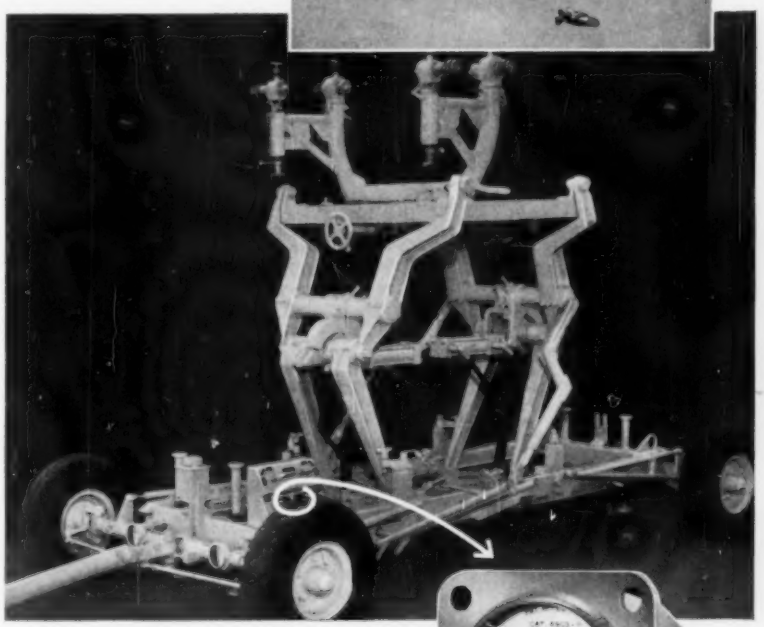


3000 psi. Qualified for missile systems; reports are on file. Chromic anodized aluminum body and pas-

Continued on page 118

At the right a McDonald *Green Quail* Missile is being launched from a B-47. The *Green Quail* ground support trailer is shown below.





Trailer mounted RMC-Lindsay pressure gauges give fast, dependable systems check for unerring flight of Green Quail

Fast, because they are designed for maximum readability and quick response. Dependable, because of their simple direct-drive operation and precise construction.

The RMC-Lindsay gauge is completely different from the usual pressure gauge. Instead of the common "C" type bourdon tube, the RMC pressure element is a helical bourdon coil which offers greater resiliency and longer accurate cycling life. Instead of the pointer being actuated through the usual linkages, gears, hair springs and the like, the RMC pointer is attached directly to the end of the helical bourdon pressure element. This eliminates waver and lag, wear and slippage; provides exceptional resistance to the destructive effects of vibration, shock and pulsating pressures.

For complete information, write, wire or phone:

ROCHESTER MFG. CO. OF CALIFORNIA
1401-C S. Shamrock Avenue, Monrovia, Cal.

ROCHESTER MANUFACTURING CO., INC.
209-C Rockwood Street, Rochester 10, N.Y.

RMC
LINDSAY PRESSURE GAUGES

Circle **143** on Reader-Service Card

2 NEW! STRATOFLEX HYDRAULIC COUPLINGS

Thanks to non-metallic seals, the new Stratoflex all-purpose couplings guarantee a positive self-sealing unit when connected or disconnected. When the two halves are connected, the valves open automatically to assure maximum flow, with a minimum of pressure drop.

Stratoflex Self-Sealing Couplings are available in three designs: wing nut, hex nut and knurl sleeve, with NPTF Pipe Thread or SAE "O"-Ring Boss Thread, in sizes ranging from ¼" to 1¼".

Stratoflex Quick-Disconnect Couplings are furnished in NPTF Pipe Thread and SAE "O"-Ring Boss Thread, with a size range from ¼" to 1".

For complete information on Stratoflex Hydraulic Couplings, write for Stratoflex Bulletin S-6 immediately.

STRATOFLEX Inc.

P.O. Box 10398 Fort Worth, Texas
Branch Plants: Hawthorne, Cal., Fort Wayne, Toronto
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Milwaukee, New York
Orlando, Philadelphia
Pittsburgh, San Diego
San Francisco, Seattle
Toronto, Tulsa

Circle **125** on Reader-Service Card

AEROSPACE COMPONENT DATA

sivated stainless steel spring. Leakproofed by twin O-rings in machined grooves around plug periphery. O-ring material may be varied.

Specifications: Weighs 0.06 lb. Operates at temperatures from −65 F to 300 F and pressures from 0 to 3000 psi. Flow rates from 40 to 60 ifm at 3000 psi.

Designation: P-416 type—*James, Pond & Clark, Inc., Pasadena, Calif.*

Circle **515** on Reader-Service Card

Lightweight, 3-Way, Solenoid Valve

Features: 3-way, 3-position, solenoid-operated, spool valve controls high pressure fluids in aircraft emergency power systems for hydraulic motor supply and return lines. Valve selects from either of two independent sources of supply or shuts off all supply and return ports. Two-piece spool permits minimum bore clearances by reducing the valve bore length.

Specifications: Twin, 1.5 amp, 18-30-vdc solenoids. NC, neutral when de-energized. Inlet pressure range is 700 to 3000 psi, with temperatures from −65 to 160 F. Weight is 3.9 lb.—*AiResearch Manufacturing Div., The Garrett Corp., Phoenix, Arizona.*

Circle **516** on Reader-Service Card

Cryogenic Dynamic Seal

Features: No leakage at temperatures from −423 to 400 F in contact with liquid hydrogen, nitrogen, and oxygen. Fits into external or internal O-ring grooves. Seal consists of a seal ring of Teflon and a spring ring of stainless steel. The ring is oval in cross section and wound at a slant angle to provide the sealing load.

Specifications: For rotating or reciprocating applications at pressures from vacuum to 20,000 psi. Stock sizes from 3/16" to 2⅜" diameter. Also available for use in acids, fuels, and very low friction applications.

Designation: Bal Seals.—*Balsells Engineering Co., Santa Fe Springs, Calif.*

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Circle **86** →

THREE GREAT SERIES

A MARSH Valve for every purpose

Yes, three great series of needle throttling valves. Great in design and construction. Great in range of corrosion resistant service. Great in range of sizes and patterns.

All three series share the basic design and construction that has set new standards for Marsh Needle Valves.

All give smooth, close regulation and positive shut-off from a few pounds pressure up to high pressures.

All have body and stem guides machined from solid bar stock to provide extra strength and valve life.

All have precision ground stems and long fine-pitched accurately-machined stem threads for micrometer regulation and tight shut-off.

All have deep inlet and outlet threads for tight make-up.

All have special, long-lasting, readily-replaced, special "Marpak" packing incorporating all-but-indestructible Teflon in the stainless steel series.

You see a globe valve representing each series here. Note that the color of the handle identifies the series. Valves come to you individually sealed in strong, transparent plastic packages. In appearance, in operation, in service life you have in these valves the kind of product that only Marsh experience in *both* valve making *and* instrument making could produce.

Globe and angle valves in all three series are available with double female connections in sizes ⅛", ¼", ⅜", ½", ¾" and 1"—with male inlet and female outlet in sizes ¼" and ½". Panel mounted types in all sizes. Write for bulletins.

Ask for bulletins

These three bulletins, covering alloy steel, 416 stainless steel, and 316 stainless steel valves will be sent to you in a binder. Write.

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Marsh Instrument & Valve Co., (Canada) Ltd.,
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Houston Branch Plant, 1121 Rothwell St.,
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MARSH *Needle Valves*

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National BUD UNITIZED has integral wear ring presenting rubber surface to shaft. Wear ring turns with shaft, sealing lip is never exposed to damage, cannot score shaft.

A new unitized oil-seal-and-wear ring that eliminates:

SHAFT WEAR OR SCORING

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COSTLY SHAFT RE-MACHINING

SEALING LIP INSTALLATION DAMAGE

SPECIAL INSTALLATION PROCEDURES

New National BUD UNITIZED seals are now in production, in a limited range of sizes, for heavy oil and grease sealing applications — including truck, bus and tractor uses. Still newer BUD UNITIZED seals are on the way for higher speed automotive and similar uses.

Changing a National BUD UNITIZED oil seal automatically changes the wear sleeve — in one fast, simple operation. Since the seal has its own integral wear ring, it is almost impossible to install it other than squarely on the shaft. Expensive shaft finishing is no longer a necessity, nor is leakage under a metal wear ring a problem — both thanks to the rubber surface BUD UNITIZED presents to the shaft.

For complete details or skilled engineering help on application of BUD UNITIZED seals, write direct, or call your National Seal Applications Engineer. You'll find him in the Yellow Pages, under Oil Seals.

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Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Redwood City and Downey, California

Circle **92** on Reader-Service Card

6013-R

AEROSPACE NEWS

from the fluid power field

Pall Corp. names vice president, appoints manager

Henry Petronis has been appointed vice president-manufacturing of the Pall Corp., Glen Cove, N. Y. He will be responsible for all manufacturing operations of the Pall Corp. and its subsidiaries and divisions, in addition to his present function as president of Glen Components Corp., precision machining subsidiary of Pall.

Farris

Petronis

John A. Farris has been named manager of engineering liaison by Aircraft Porous Media, Inc., another subsidiary of Pall Corp. Farris is a member of the SAE Committee A-6 Contamination Control Panel and the Filters Standards Panel.

Hydraulic Research wins actuator contract, appoints contracts manager

Hydraulic Research and Manufacturing Co., Burbank, Calif., has received a contract from Convair Astronautics, for electrohydraulic steering actuators for the Atlas missile. S. A. Baker, secretary-treasurer of Hydraulic Research, has been appointed manager of contracts. He has been with the firm since 1954.

General Controls to produce capsulated valve

The Aircraft/Electronic Controls Div. of General Controls Co., Burbank, Calif., has received a contract to produce a special solenoid-actuated switching valve for use in the Bomarc B missile. The valve is completely capsulated in the ramjet engine. Advanced design makes the valve smaller and more reliable. The project is headed by engineering manager John P. Etcheverry.

Wiggens Connectors appoints Muenchow

Ralph H. Muenchow has been appointed senior field engineer for Wiggens Connectors. He will be located in Dayton and will be responsible for sales of Wiggen's products in Ohio and Michigan.

Analyzer measures valve operating time

An automatic valve operation analyzer for measurement of time intervals in sequential operation of solenoid-operated valves or relay-actuated components has been introduced by Consolidated Avionics Corp., Westbury, N. Y. The unit

also provides position time plots for linear or non-linear valve motion. The unit measures time intervals as short as 0.1 millisecond and presents the readings in printed form and graphically. As many as 12 sequential events occuring within three seconds can be automatically timed.

Continued on page 122

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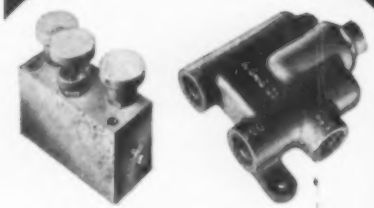

Manifold Valve • Sequence Valve

- Machined aluminum body
- Combines two adjustable relief valves and needle valve
- Permits selection of different operating pressures
- Cast aluminum body
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- Capacity 7 gpm
- Operating pressure 3,000 psi

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combining Modular-Cartridge type valves designed and produced to your specifications.

Custom produced as individual modular-cartridge type valves for insertion into your manifold or as a completely integrated manifold assembly, these valves simplify circuitry—permit greater design freedom and substantial cost and weight reduction.

The modular - cartridge valves may be removed for servicing without disconnecting any lines and reduce leakage points, connectors, fittings and lines.

The illustrated valves are another example of Fluid Regulators capabilities to produce many types of valves that meet specific user requirements. Contact us today, for prompt action on specific problems.

Fluid Regulators CORPORATION

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Circle **50** on Reader-Service Card

AEROSPACE NEWS

from the fluid power field

Airline manager inspects REF test stand

Rudolph Christensen of Scandinavian Airlines System spent several days recently at REF Manufacturing Corp., Mineola, L. I., N. Y., checking out a large, hydraulic accessories test stand built for SAS. Christensen is manager of engine and accessory overhaul in Copenhagen. The new test stand was specifically designed to check all hydraulic components on DC-8 jet aircraft.

SPECIAL DESIGN FEATURES of the new hydraulic test stand are pointed out by Morris Rochman (right), president of REF Manufacturing Corp., to Rudolph Christensen.

Hydro-Aire joins Crane group

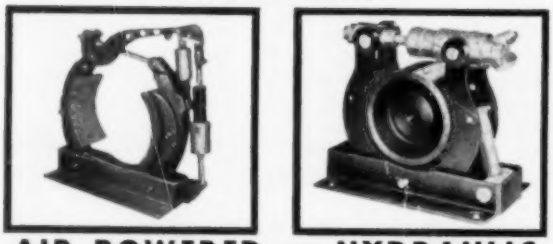
Hydro-Aire Company, Burbank, Calif. has become part of the recently formed Systems and Control Group of the Crane Company. A division of Crane since 1951, Hydro-Aire is joined in the new group by Chapman Valve Manufacturing Co., and Swarthout Company, two other divisions of Crane. In charge of the group will be Dale A. Lichty, president of Hydro-Aire for the past three years.

Pesco fuel pump manufactured by Lucas-Rotax

Aircraft fuel pumps developed by Pesco Products Division, Borg-Warner Corp., Bedford, Ohio, will be manufactured in Canada by Lucas-Rotax, Ltd. The pump will be used on General Electric's J-79 engine for the Lockheed F-104 aircraft, for which Lucas-Rotax is a major supplier of engine accessories.

STOP EQUIPMENT SAFELY

with Wagner



AIR POWERED or HYDRAULIC BRAKE SYSTEMS

Wagner makes both air powered and hydraulic industrial braking systems that stop your equipment safely, easily, economically.

WAGNER AIR POWERED BRAKING SYSTEMS use the same heavy-duty brakes that Wagner builds for hydraulically operated overhead crane brakes. Application is flexible . . . any number of brakes and control points may be used at reasonable distances from each other.

WAGNER HYDRAULIC BRAKE SYSTEMS let you put the *right* braking system on your large or small cranes. Example: new 6" x 3" size brakes are perfect for floor-operated or small cab-operated cranes.

Let your nearby Wagner Sales Engineer help you select the braking system best suited to your needs. Call him today.

W160-4

Wagner Electric Corporation

6367 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

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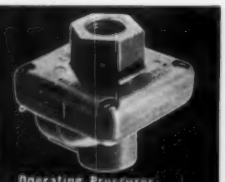
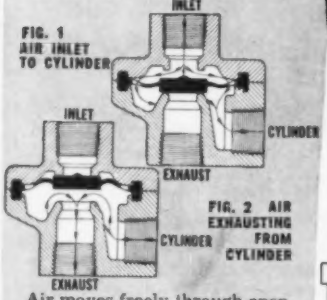
Circle **16** on Reader-Service Card

NEW! Pneu-trol® QUICK EXHAUST VALVE

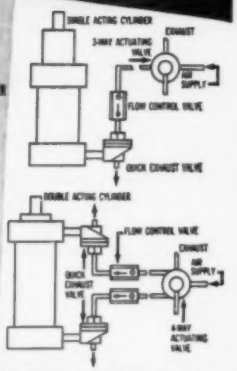
Fast air dumping AT THE CYLINDER permits use of smaller valves and piping . . . INCREASES EFFICIENCY AND SPEEDS



Operating Pressures:
1 to 125 PSI
For ¾" and ¼" pipe sizes



Air moves freely through open passages formed by 12 holes spaced around periphery of diaphragm and into cylinder (Fig. 1). When inlet pressure is relieved (by actuating valve in control circuit) the buildup of cylinder return pressure closes inlet holes and snaps the plug off exhaust port (Fig. 2) closing inlet port and allowing instantaneous evacuation of exhaust air. *Write for complete details, specifications and prices.*



TYPICAL APPLICATIONS of Quick Exhaust Valves in Single and Double Acting Cylinders. Because exhaust air is dumped at cylinder, smaller diameter piping and smaller selector valves can be used.

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FOR **AIRBORNE & TEST CELLS**

- Precision and regulation, to 3°F or better by multiple temperature controls.
- 24 volts AC or DC or 115 Volts AC, DC less than 60 watts.
- Field adjustable or fixed reference temperature with built in resistance temperature monitor.
- From 5 to 30 circuits in any standard combination of thermocouple wire.
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- Ambient of —65 to +200°F causes less than 3°F change in control temperature.
- Can be rack mounted for test cell operation.

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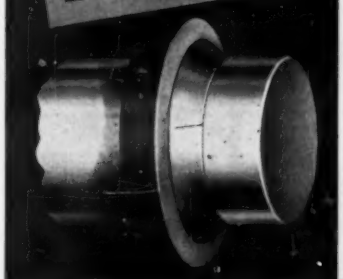

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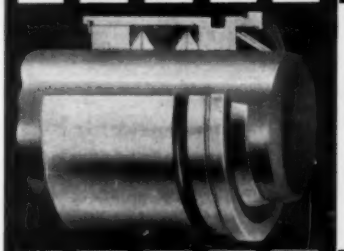
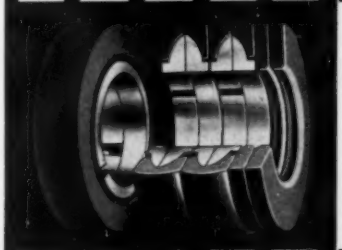
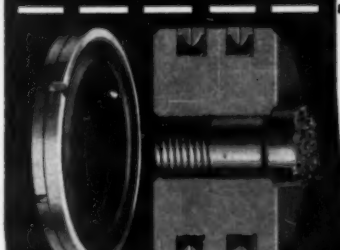
METALLIC ROD WIPERS
"Wipe off" dirt accumulation with rubber mounted, flexible bronze knife edges. Perform better, for longer.



MONOPAK CARTRIDGE
Compact, all-in-one package of packing, bearings, and rod wipers. Air or hydraulic cylinders. No machining or adjustments.



MONOPAK ROD PACKING
A highly efficient bearing and seal package for air or hydraulic use. Available in all desired sizes.



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A long lived, trouble-free, automotive type ring and packing for one or two piece pistons.

YOUR ASSURANCE OF BETTER PNEUMATIC OR HYDRAULIC SEALING.

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Pipe Line Sizes ¼"–⅜"–½"–¾" and 1"

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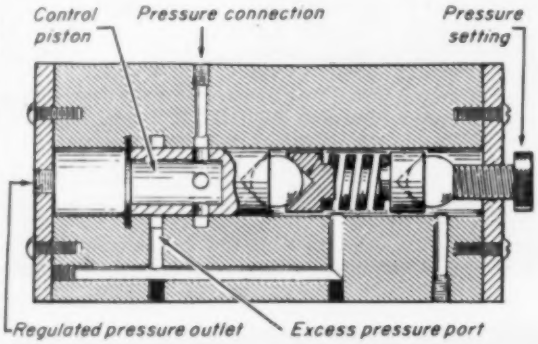
FLUID POWER PATENTS

Pressure Regulating Valve

The purpose of the valve is to regulate pressure in a hydraulic line regardless of any action in the circuit tending to build up pressure in the line downstream of the valve.

• **Operation**—The valve is connected to a source of high pressure fluid through its pressure connection. Fluid enters the valve through this connection, and flows through the orifices in the control piston and out



the regulated pressure port. This piston remains stationary until pressure in the regulated-pressure line increases enough to overcome spring force. The piston then moves right and its orifice moves out of alignment with the orifices in the valve body.

When pressure in the regulated-pressure line drops, the piston moves left aligning the orifices and allowing a greater quantity of fluid to flow.

If flow from the regulated-pressure port is blocked and pressure downstream builds up, the piston moves right and uncovers the excess pressure port. Fluid is relieved to tank through the passage in the valve body and through the spring chamber.

U. S. Patent No. 2,940,463 by Ronald Balfour, assigned to Orenda Engineers Ltd., Ontario, Canada.

Dual-Piston Accumulator

Leakage in either direction past the piston of a piston-type accumulator reduces its effectivness. If gas leaks into the liquid, precharge pressure falls and the system becomes spongy. If liquid leaks past the piston, volume of the gas chamber is reduced. Here's a recently-issued patent for an accumulator design that prevents intermixing of gas and liquid.

• **Operation**—The accumulator is precharged or connected to a source of gas under pressure at the connection on the left. The chamber at the rod end of the

Continued on page 126

Circle **69** on Reader-Service Card

this is *SEAL-GUARD®!*

the modern, truly efficient rod-wiping component

The modern and most effective means for keeping your hydraulic and pneumatic systems clean is with *Seal-Guard.* This rod-wiping component consists of (1) two knife-like bronze wiper rings which throw all foreign matter outward as rod retracts into cylinder and (2) a synthetic rubber retaining ring which absorbs shock and side load, holds wipers in full contact with rod and provides an overall outside seal.

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DESIGNED FOR VOLUME USERS

★ LOW-COST
★ DEPENDABLE
★ VERSATILE
★ TROUBLE-FREE

SPECS IN BRIEF...

SIZES: ⅛" to ¾" NPT.

PRESSURE RANGES: Up to 2000 PSI for brass and aluminum. Up to 5000 PSI for steel or stainless.

MATERIALS: Stocked in brass and steel. Available in stainless, aluminum, and other alloys to order.

FEATURES: Low initial cost and less maintenance. High flow-to-size ratios. "Straight-thru" principle cuts friction loss and clogging. Easy to install.

USED BY the biggest names in American industry . . . and in military applications.

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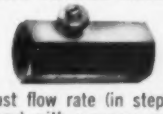
CHECK VALVES

'Straight-thru' design for highest flow and dependability. Free-moving ball principle.

FLOW CONTROL VALVES



Adjust flow rate (in stepless ranges) with common screwdriver before, during, or after easy installation.

DUAL CONTROL VALVES

Unique . . . controls flow in both directions independently! True 2-way control for little more than the cost of one flow control valve.

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Precision Parts Assure Precision Performance from O-M Cylinders!

Internal Key Tie-Rodless Type Series 101A Air—150 psi—up to 1500 psi Hydraulic. Fits where others won't Bulletin 101A

ALL O-M CYLINDERS MEET JIC STANDARDS

With all matching parts and mounts machined to close tolerances, O-M Air and Hydraulic Cylinders eliminate misalignment friction, unnecessary wear on rod, bearings packings, also reduce maintenance, when operated singly or in sequence under automatic cycling. The length and direction of piston rod travel is accurately controlled whether the job calls for moving a machine member, holding a tool, positioning, clamping, releasing a work piece, activating an indexing table or other applications. In addition, precise cushioning against piston shock on thrust and return strokes makes for smoother, dependable operation.

O-M Cylinders are available in a complete range of sizes (1½" to 8" bores) with standard or heavy-duty rods. Complete line of interchangeable parts and mounts. Immediate delivery on most sizes.

If you are designing air or hydraulic cylinders into original equipment for precision control of linear motion, coupon below will bring our latest bulletins showing construction and dimensional details, engineering drawings, capacity chart and mounting data. For your copies, **MAIL COUPON TODAY.**

Bulletin 101A for Internal Key Tie-Rodless type Air and Hydraulic Cylinders featured above.

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Bulletin 107—Automation (Heavy Duty) Air Cylinder for 200 psi operation.

Bulletin 108—Automation (Heavy Duty) Hydraulic Cylinder—for 1000 psi operation.

ORTMAN-MILLER MACHINE COMPANY
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Send Bulletins

☐ Have representative call ☐ 101A ☐ 105A ☐ 107 ☐ 108

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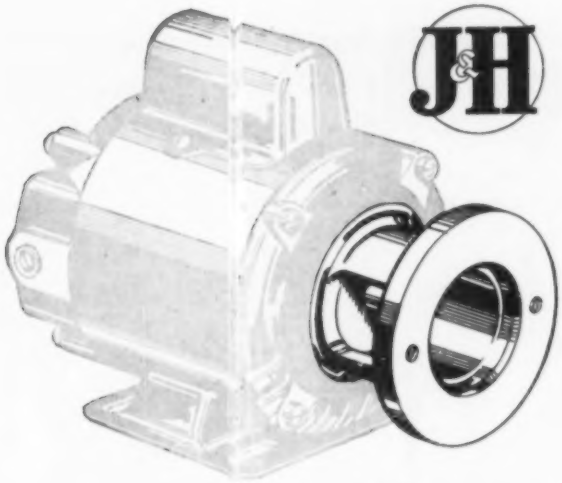

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Right at this coupling, there is a meeting of minds between pump designer and motor designer. Jack & Heintz can build the drive end to suit your individual requirements for mounting, alignment or coupling—just like that!

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SPEEDS: 3450, 1725 or 1140 rpm
FRAME: J66 or special
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Customized
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ELECTRIC MOTORS

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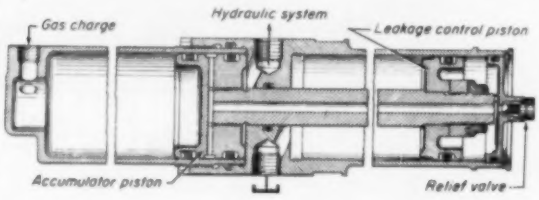
FLUID POWER PATENTS

accumulator piston connects to the hydraulic system. The piston rod extends through a separator and connects to a leakage control piston.

The accumulator piston has an annular groove between two O-rings. This groove connects to a passage through the piston rod to the head end of the leakage



control piston. A relief valve in the end cap maintains only a few pounds pressure in this chamber. Relieving the pressure between the piston seals increases the pressure drop across the seals giving a greater sealing force.

Fluid that leaks by the seal dividing the cylinders returns to tank through the port in the rod end of the leakage control cylinder.

The relief valve not only maintains a low pressure in the head end of the leakage control cylinder, but it also prevents dirt from entering the cylinder when the piston moves left.

U. S. Patent No. 2,937,663 by Benjamin N. Ashton and Raymond J. Barton, assigned to Electrol Inc., Kingston, New York.

Other Patents Issued

FLOW REGULATOR
No. 2,917,269 by Robert H. Walker, Houston, Texas.

DIAPHRAGM VALVE
No. 2,916,255 by Gordon T. Koehler, assigned to Koehler Aircraft Products Co., Dayton, Ohio.

PUMP CONTROL
No. 2,921,439 by Fredrick G. Krafft and Walter Ernst, assigned to The Thompson Grinder Co., Springfield, Ohio.

SERVOMECHANISM
No. 2,992,400 by Herman R. Lorence, assigned to Hughes Tool Company, Houston, Texas.

DIVERTER VALVE
No. 2,919,717 by James G. Bradbury, assigned to Hays Manufacturing Co., Erie, Pa.

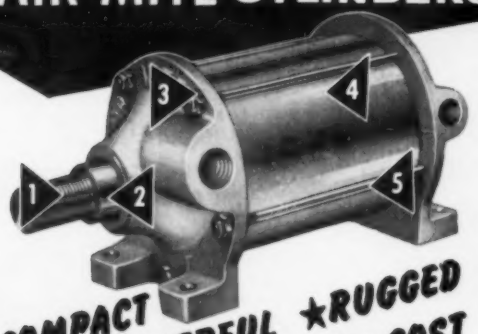
PNEUMATIC CONTROL VALVE
No. 2,921,158 by Wesley L. Taylor, assigned to The Dole Valve Company, Morton Grove, Ill.

PRESSURE REDUCER
No. 2,920,647 by Jean Mercier, New York, N. Y.

VARIABLE VOLUME PUMP
No. 2,922,376 by Melvin C. Hankel and Burdette W. Foss, assigned to Tokheim Corp., Fort Wayne, Ind.

Circle **8** on Reader-Service Card

AIR-MITE AIR CYLINDERS



★COMPACT ★POWERFUL ★RUGGED ★LOW COST

AIR-MITE Cylinders—made in Single or Double Acting Series, in 4 mounting types, are high quality cylinders at a low price. Simple, rugged design and compact construction give them long life, permit easy mounting on jigs, fixtures, tools, or machines. Used wherever power holding, pushing, pulling, or lifting is required, AIR-MITE Cylinders will meet your most exacting requirements of dependability and long life. Write for complete catalog and prices.

QUALITY FEATURES:

1. Ground and polished steel ram
2. Bronze oilless ram bushing
3. High strength aluminum alloy cylinder heads
4. Brass, true-bore cylinders
5. Five steel tie rods

92

AIR-MITE DEVICES, INC.

4801 W. Kinzie St., Chicago 24, Ill.

LOCK OUT AIR FOR MACHINE REPAIR

Ross

Locks
Out and
e**X**hausts
VALVE

Lock out air that operates a machine, as a safeguard when making machine repairs. The Ross L-O-X Valve installs in the supply line leading to the machine, upstream of any operating valve. Designed so that when closed, supply-air to the machine is shut off and air downstream is exhausted. Can be padlocked in this position.

More L-O-X valves can be incorporated in the circuit to shut off and exhaust various segments of the circuit. Detented open; very low pressure drop; Lightweight aluminum construction. Call your Ross representative or write for literature.

ROSS OPERATING VALVE CO.

105 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

Circle **117** on Reader-Service Card

STAFFA

HIGH TORQUE VARIABLE SPEED (1-100 r.p.m.) HYDRAULIC MOTORS

Mark IV—5 cylinder 4,500 lbs. ft. at 2,000 p.s.i. (Speed 1—100 R.P.M. reversible). Overall efficiency 90%—95%.
Mark V—7 cylinder 6,600 lbs. ft. at 2,000 p.s.i. (Speed 1—75 R.P.M. reversible). Overall efficiency 90%—95%.
Ideal drive for conveyors, rolling mills, cranes, tractors, cement mixers, drills, and most mechanical handling applications.

4" HYDRAULIC BENDER

Standard equipment includes 2"—4" formers for steam and gas pipes. The machine can be supplied either **Hand Operated** or **Motorised** and accessories are available for ⅜"—1½" steam and gas pipes, flat bar bending up to 7" x ¾" section and electrical conduits up to 3".

A complete range of Hydraulic Pipe and Tube Benders ¼" to 18" dia. Pipes is available.

CHAMBERLAIN INDUSTRIES LTD.

Staffa Works, Argall Ave., Leyton, London, E.10, England.
Leytonstone 3678
(MEMBER OF THE CHAMBERLAIN GROUP OF COMPANIES)

Circle **34** on Reader-Service Card

This is a pressure-drop indicator

. . . it is used to continuously indicate pressure drop across hydraulic and pneumatic filters. As part of its high-pressure construction, no physical connection exists between the moving pointer and the pressure chambers . . . magnetic coupling.

Bulletin 91914 provides all the technical details. Send for it.

there's a lot of magic in B & F servo components.

Boonshaft and Fuchs Inc.

HATBORO INDUSTRIAL PARK • HATBORO • PA.

Circle **27** on Reader-Service Card

NEW PRODUCTS

Continued from page 56

NEEDLE VALVES

In 316 stainless steel. Teflon packing. Same basic design features as Marsh alloy steel and 416 stainless steel needle valves. Globe, angle, and panel-mounted types.

Specifications: For pressures to 6000 psi, temperatures from −100 to 500 F. Sizes are ⅛", ¼", ⅜", ½", ¾", and 1".

Designation: Series 1936—*Marsh Instrument Co., Div. Colorado Oil & Gas Corp., Skokie, Ill.*

Circle **312** on Reader-Service Card

MAGNETIC LINE STRAINER

Built-in, circular Alnico magnets are between removable filter disc screens. Screens remove non-magnetic matter. When strainer is disassembled, iron and magnetic filings drop off disc covers. Meets JIC.

Specifications: Strainers can trap particles from .003" to .005".—*Ripley Screen & Strainer Co., Filter Div., Farmington, Mich.*

Circle **313** on Reader-Service Card

GAGE PROTECTOR

For gas. Pressure protection point can be adjusted without removing protector from system. Stops flow to gage when protection point is reached. Automatic reset when pressure drops below protection point. Can be threaded directly to gage. Brass body and piston. Buna N O-rings.

Specifications: 1¾" long. Maximum protection point is 1000 psig. Handles inlet pressures to 3000 psig at −10 to 200 F. Inlet and outlet connections are ¼ NPT female. Three range springs cover 30-150, 150-500, and 500-1000 psig.

Designation: 530 Gauge Protector —*Hoke, Inc., Cresskill, N. J.*

Circle **314** on Reader-Service Card

PRESSURE BALANCES

Rapid enough for production-line calibration of pressure gages and transducers. Automatic weight lifters raise and lower weights by flipping a toggle valve. Pilot lights show balance. Weights not in use can be subtracted from weighing system without removing them from the balance.

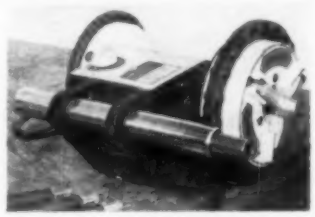
Specifications: Accuracies to 1/20th of one percent. Models have upper limits of 10,000, 15,000, 20,000, 50,000, and 100,000 psi.

Designation: Aminco line—*American Instrument Co., Inc., Silver Spring, Md.*

Circle **315** on Reader-Service Card

HOSE ASSEMBLY MACHINE

One-man machine grips work firmly in right and left directions. No need to hammer chuck closed or open. Unit also has universal-centering rear chuck. Telescoping arm for driving a wrench in assembling. Sealed, lubricated bearings and gear case. Requires no special servicing or maintenance. Powered by a 115-vac, ½-hp motor.



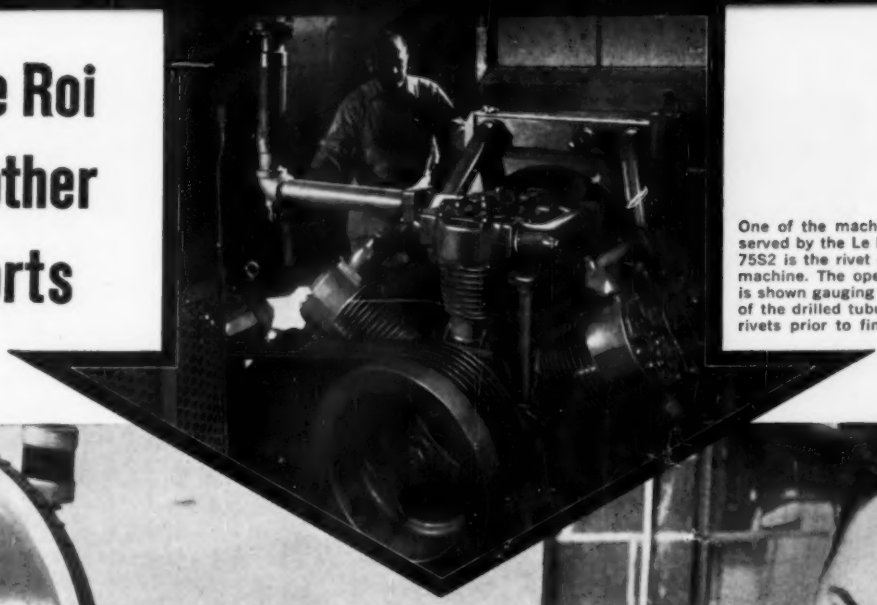
Designation: Model T-1500—*Weatherhead Co., Ft. Wayne.*

Circle **316** on Reader-Service Card

Continued on page 130

Circle **80** →

One good Le Roi leads to another ...user reports



One of the machines served by the Le Roi 75S2 is the rivet drilling machine. The operator is shown gauging one of the drilled tubular rivets prior to finishing.

LE ROI 75-HP STATIONARY COMPRESSOR

First air-cooled Le Roi finishes 5 years of service with just routine cleaning and oil changes!

Shown above is a Le Roi 75S2 compressor recently installed at John Hassall, Inc., Westbury, Long Island, manufacturer of job-designed fasteners and parts.

Picking Le Roi came naturally when Hassall found need for additional air power. Their last Le Roi has worked for five years without trouble, and has required only filter cleaning and oil changes for upkeep.

Hassall was convinced they could save 30% on installation, get more air from less space, and reduce maintenance time about 40% if they installed the air-cooled Le Roi 75S2 rather than a water-cooled air compressor.

Moreover, Le Roi compactness permits installation *near the point of use*, with less piping and air loss. Air-cooling eliminates costly plumbing and water-line freeze-ups... permits indoor or outdoor installation. Dual control gives you constant speed or automatic start-stop operation.

Pick Westinghouse unit-type or Le Roi stationary air compressors for your needs. Sizes from ½ to 100 hp. See your Le Roi distributor, or write to Le Roi Division, Westinghouse Air Brake Co., Sidney, Ohio.

SC-67

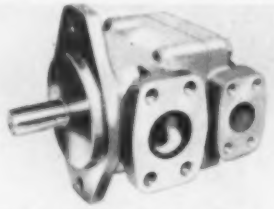
LE ROI STATIONARY COMPRESSORS

PORTABLE AND TRACTAIR® AIR COMPRESSORS • STATIONARY AIR COMPRESSORS • AIR TOOLS

NEW PRODUCTS

VANE PUMPS

Housing has ball bearing, shaft seal, and inlet connection. Pumping cartridge has rotor, vanes, cam ring, and floating front-port plate. End cap has roller-bearing assembly and outlet connection. This bearing and ball bearing in housing support shaft. Port plate is free to move axially within limits. This permits cold starts and pressure



loading. Leakage goes back to suction. No drain lines. Standard 2-bolt, C-type SAE mounting flange. End cap can rotate to four positions. Port pads match 4-bolt SAE port pads.

Specifications: For continuous operation at pressures to 2500 psi. For speeds to 2500 rpm. Rated at 8, 11, 14, and 17 gpm at 1200 rpm, 0 psi.

Designation: TIC series.—*Denison Engineering Div., American Brake Shoe Co., Columbus, Ohio.*

Circle **317** on Reader-Service Card

ON THE JOB...

with CROSS HYDRAULIC CYLINDERS

Stay "on the job" with dependable, rugged Cross Hydraulic Cylinders. Like Cross customers everywhere, you too, will appreciate the fast, courteous, dependable service you get from Cross. Phone for speedy delivery on any quantity...quality-built to your specifications. Contact Cross Engineering Department, today!

- RUGGED
- DEPENDABLE
- ECONOMICAL

CUSTOM DESIGNED CYLINDERS FOR EVERY APPLICATION

Try CROSS CYLINDERS in your operation... low cost, dependable, and trouble free.

Lowest-Priced Engineered Quality Cylinders Available..

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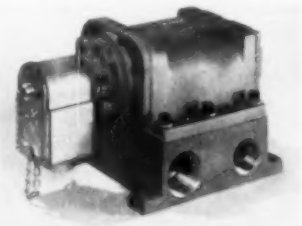
LEWIS, KANSAS—PHONE EA 4-5525

WRITE • WIRE • PHONE...TODAY!!

Circle **40** on Reader-Service Card

4-WAY AIR VALVE

2-position, poppet-type valve is sub-base mounted. Replaceable, resilient seals cushion moving parts.



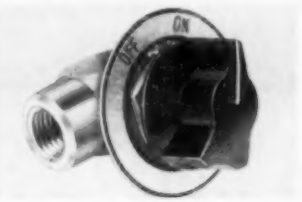
Tapered sealing surfaces. Internal parts are interchangeable with those of other 3 and 4-way valves.

Specifications: 1" capacity. Ports are ¾", 1", and 1¼" NPT.—*Hoffman Valves, Inc., Dayton.*

Circle **318** on Reader-Service Card

QUICK-OPENING VALVE

For panel mounting. Operates in less than ¼ of a turn. Machined from brass bar stock.



Specifications: 2-way valves for 400 psi. 3-way valves for 125 psi. 3/16" orifice. In all combinations of ⅛" and ¼" male and female pipe ports and ⅜" male pipe ports.—*Generant Engineering Co., Newark.*

Circle **319** on Reader-Service Card

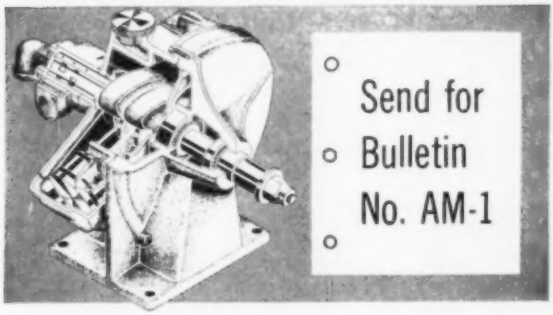
MINIATURE AIR SWITCH

Magnet-actuated switch is for pneumatic circuits where only a very low actuating force is available. No mechanical linkage or striking parts. Can replace electrical components. Snap action when energized or de-energized by a small magnet on a

Continued on page 132

Circle **52** on Reader-Service Card

Start heavy loads smoothly with high-torque air motor



Here's an air motor that develops high starting torque . . . maintains smooth power under all speed and load conditions. Gardner-Denver's 5-cylinder design provides overlapping power impulses. At least two cylinders are always on power stroke—three during part of cycle. Starts heavy loads easily . . . accelerates smoothly. Six sizes from 2 to 16 hp. Direct drive or built-in gear reduction. Reversible and nonreversible models.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

Gardner-Denver Company, Quincy, Illinois
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GARDNER - DENVER

Kep-O-seal

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*Flexible Seal Seat** VALVES

- CHECK VALVES
- RELIEF VALVES
- SHUTTLE VALVES
- CARTRIDGE VALVE INSERTS

Specify Kep-O-seal! — leakproof construction designed for efficient fluid flow and reasonable cost. This name is your assurance of quality; backed by two generations of specialized service to industry.

*PAT. APP'D. FOR.

Write for Complete Detailed Information.

KEPNER PRODUCTS COMPANY
7321 West 59th Street Summit, Illinois

Circle **78** on Reader-Service Card

GENERAL *Industrial* FILTERS

AF-500 and AF-500C CLEANABLE WOOL FELT

Famous for its line of fluid filters, the General Filters' 500 series is highly representative of Generals' recognized efficiency. The model illustrated, built in two sizes, incorporates a *cleanable* wool felt element and is especially recommended for economical protection of hydraulic oils, lubricating oils, hydrocarbon liquids, paints and varnishes. Lifetime iron and steel construction. Install with inlet at top or bottom. Wool element with wire screen core to prevent collapsing, 5 or 15 microns, cleans easily in any suitable solvent.

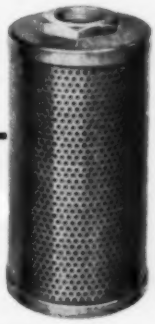
AF-500-X SERIES with THROWAWAY Cartridge

For quick filter changes with minimum machine shutdown the "X" series is a proved performer. Choice of three phenol resin-treated pleated paper *throwaway* cartridges: 5, 15, or 35 microns. BIG filtering area — 3000 sq. in. — ideal for lowest cost performance.

AF-500 CM and CMS HIGH PRESSURE

Heavy-duty model for working pressure up to 1000 psi. Available in two sizes. Same cleanable wool felt element used in AF-500 filter.

3000 SERIES SUMP TYPE FILTER



Five sizes from 8 to 50 gpm. Monel mesh screen pleated element for submerged installation. Can be installed individually or in multiples of two or more for greater capacity. 100-mesh standard — other sizes available.

10 MONEY SAVING MODELS

General Filters' wide range of fluid filters provide maximum service and performance for practically any industrial application. Meet J.I.C. standards. Write for information and prices.

GENERAL FILTERS, Inc.
43800 GRAND RIVER AVE. • NOVI, MICHIGAN
In Canada: Canadian General Filters, Ltd.
39 Crockford Blvd., Scarborough, Ontario

Circle **56** on Reader-Service Card

HOW YOU SAVE...

...getting drier Compressed Air

Direct saving in the cost of cooling water saves the price of the Niagara Aero After Cooler (for compressed air or gas) in less than two years.

Extra, for no cost, the drier air gives you a better operation and lower costs in the use of all air-operated tools and machines, paint spraying, sand blasting or moisture-free air cleaning. Water saving also means less expense for piping, pumping, water treatment and water disposal, or you get the use of water elsewhere in your plant where it may be badly needed.

Niagara Aero After Cooler assures all these benefits because it cools compressed air or gas below the temperature of the surrounding atmosphere; there can be no further condensation in your air lines. It condenses the moisture by passing the air thru a coil on the surface of which water is evaporated, transferring the heat to the atmosphere. It is installed outdoors, protected from freezing in winter by the Niagara Balanced Wet Bulb Control.

Write for Bulletin No. 130.
Address Dept. AH-12.

NIAGARA BLOWER COMPANY
405 Lexington Ave., New York 17, N.Y.
District Engineers in Principal Cities of U. S. and Canada

Circle **93** on Reader-Service Card

NEW PRODUCTS

moving mechanism. Can be used as limit or proximity device. Can be coupled directly to relay valves in cut-off and sequential circuitry.

Specifications: Is 1⅝" long x ½" dia. Maximum pressure is 25 psig.

Bleed rate is .05 scfm at 10 psig when deenergized, zero when energized. Weighs less than 2 oz.

Designation: Pneumation Model 103 S—*Associated Control Equipment, Inc., Coraopolis, Pa.*

Circle **320** on Reader-Service Card

AIR FILTER

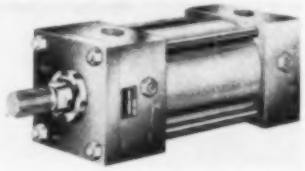
Has automatic drain. Self-cleaning. Centrifugal force spins out heavier-than-air solids. Cartridge of two Monel screens filters air. Cartridge is easily removed. Momentary differential pressures, above and below neoprene diaphragm, seal poppet valve against upper and lower seats. During travel between poppet seats, a small amount of air blows out moisture and solids which have drained into sediment bowl. No filter elements to replace.

Specifications: Lower end is threaded ¾" male pipe for pipe or hose to drain condensate. In ¾", ¾", and ½" full-area pipe sizes.
Designation: Mark ADF—*O-E-M Equipment, Cleveland.*

Circle **321** on Reader-Service Card

LOW-PRESSURE CYLINDERS

Reverse trim packings. Multiple-lip rod wiper cleans in two directions. Tube of hi-tensile brass. Pis-

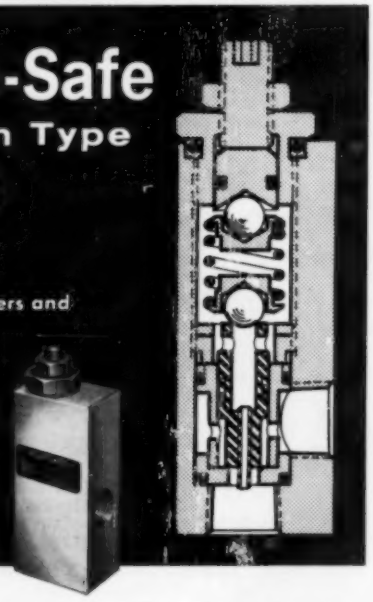


ton rod is hard chrome plated. All ferrous parts are rust-proofed.

Specifications: For 200-psi air,

Dependable-Safe
Differential Piston Type
Relief Valve
won't stick open

- Excellent in systems without filters and for hard rugged service.
- Accurate pressure control.
- Fast acting.
- Tight seal before cracking.
- Economical, sturdy design.



- Adjustable Ranges
  100 to 800 psi • 250 to 1,500 psi • 1,000 to 3,000 psi • 1,500 to 5,000 psi
- For all — ¼", ⅜" and ½" pipe (NPTF)

Write for detailed literature.

Fluid Controls, inc.
Member of National Fluid Power Association

Manufacturers of Hydraulic Valves and Devices
Relief Valves • Check Valves • Restrictor Valves
Needle Valves • Pilot Check Valves • Special Valves
Pressure Compensated Flow Regulators

P.O. BOX 186 • MENTOR, OHIO

Circle **49** on Reader-Service Card

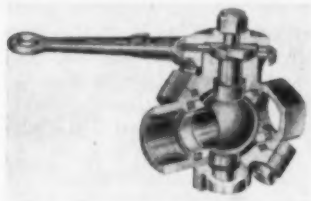
oil or water. 21 mounting styles. 11 bore sizes from 1½" to 14". Piston seals and removable, cartridge-type rod seals rated for −20 to 150 F.

Designation: Series A—*S-P Mfg. Corp., Cleveland.*

Circle **322** on Reader-Service Card

BALL VALVES

No restriction to flow. Create no turbulence, and no pressure drop. Dual seals. Mount in any position. Model which has ratchet opens



with one pull, closes with one pull. In bronze, aluminum, stainless steel, and ductile iron. Choice of synthetic rubber seals. Balls are hard chrome plated in bronze and iron valves, hard anodyzed in aluminum valves.

Specifications: Sizes from ¾" to 2". Operating pressures to 1000 psi.

Designation: Hi-Flo—*Valve Div., Besler Corp., Oakland.*

Circle **323** on Reader-Service Card

PRESSURE SNUBBER

Has 13 settings. Prevents damage and excessive wear of sensitive gages. Eliminates rapid fluctuation of needle. Selection of various combinations of three stainless steel

pins varies snubbing action. Pins have different diameters. Snubbing chamber is on side of snubber—pins can be changed without breaking line. In brass and stainless steel forgings.

Specifications: Maximum working pressure is 5000 psi. ¼" and ½" internal pipe threads.—*Republic Mfg. Co., Cleveland.*

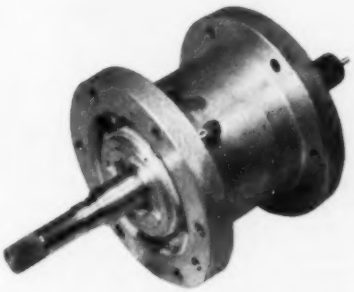
Circle **324** on Reader-Service Card

Continued on next page

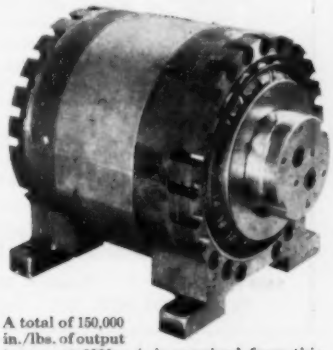
HYDROAC

MEANS EXPERIENCE

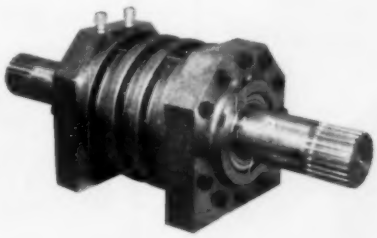
For over 15 years Houdaille has been building custom designed hydraulic rotary actuators for exacting military requirements. More recently this experience has been applied to special units for commercial use, a few of which are illustrated below. To bring the superior performance and higher operating pressures of the famous Houdaille Rotary Actuator to the greatest possible number of commercial users, Houdaille now presents the HydRoAc, offered in a complete range of standard units with custom quality performance.



This rod positioner for an atomic reactor was built by Houdaille to give 3000 in./lbs. of torque at 1000 psi.



A total of 150,000 in./lbs. of output torque at 3000 psi. is required from this Houdaille Rotary Actuator used by an airframe manufacturer for test equipment.



Houdaille Hydraulic Rotary Actuator operates at 2000 psi. to move giant radar antenna with 137,000 in./lbs. of output torque.

Houdaille Hydraulic Rotary Actuator for spinner plow operates at 1500 psi., provides output torque of 8400 in./lbs.

Send this coupon for more information on Houdaille's HydRoAc line, which offers torque outputs from 1500 to 741,000 inch pounds at operating pressures ranging from 250 to 3000 psi.

Name _____

Address _____

City _____ *Zone* *State*

Houdaille Industries, Inc.

. . . specialists in rotary type hydraulic equipment

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Circle **68** on Reader-Service Card

Circle **1** on Reader-Service Card

Fall . . . *the original*

SPRING-LOADED

Wiper **Ring**

This patented closed joint ring provides squeeze - grip action, assuring complete contact on the rod at all times. Maintains uniform, continuous pressure on wiper edge. Rods are always clean in any temperatures.

Fall "CJ" Wiper Rings operate most effectively under extreme conditions of dust, glaze, oil, grit, powder, gases, sand, ice, etc. Available in diameters ½" through 13". For any commercial use. Used by military and aviation industry since 1944.

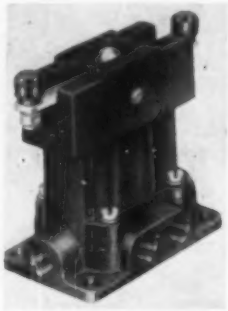
ACE PRODUCTS CO.

1838 N. 12th St. Toledo 1, Ohio
Est. 1935

NEW PRODUCTS

DIRECTIONAL VALVE

For air or oil. Poppet-type valve has removable pipe bracket. Valve can be removed without disturbing pipe



connections. Group mountings can be made, without pipe bracket, to a common manifold. 3-way and 4-way. To change operation, rearrange internal parts. Six interchangeable operators. Manual and mechanical operators can be reset, overridden, or safety-interlocked by dual air piloting. Made of die-cast zinc. All parts are non-corrosive.

Specifications: For 250 psi. Temperature range is −40 to 160 F. ⅜" and ¼" tapped pipe brackets available.

Designation: G. Pilotair—*Industrial Products Div., Westinghouse Air Brake Co., Wilmerding, Pa.*

Circle **325** on Reader-Service Card

4-SEAL T-FITTING

Eliminates need for adapters, connectors and special fittings when applying pressure gages or other instruments to fluid lines. Has four positive seals against pressure, temperature, vibration, surge. Has vibration dampener. In aluminum, brass, monel, steel, and 316 stainless steel.

Specifications: Sizes from 1/16" to 2" dia, with pipe thread.

Designation: Tylok—*C. B. Crawford Co., Cleveland.*

Circle **326** on Reader-Service Card

FLEXIBLE CONNECTORS FOR PUMPS & PIPELINES

Wire braid protects short section of corrugated flexible metal tubing against pressure elongation.

TRU-SEAL

TEFLON SEAL

Saves hours in piping installations

PAT. PENDING

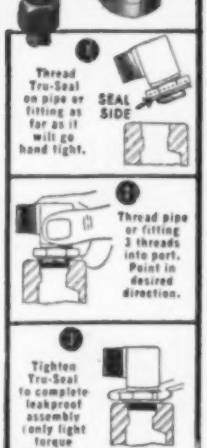
Eliminates leaks in oil, air, water, vacuum, chemical lines

Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

For further information write

TRU-SEAL DIVISION
FLICK-REEDY CORPORATION
7N017 York Rd., Bensenville, Ill.

"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into part. Point in desired direction.
3
Tighten Tru-Seal to complete leakproof assembly (only light torque required).

Circle **144** on Reader-Service Card

SOLVES tooling and automation problems **ECONOMICALLY!**

~~$15.95~~
NOW
$12.95
LIST

IMPROVED

1" STROKE
Double or Single Acting

1⅛" bore CLH SERIES heavy duty clamp type Air and Hydraulic Cylinders

The ideal cylinder for unlimited automation, tooling and production line applications where space and economy are important! Compact—only 1⅛" square. Pre-stressed construction for rugged service. Double acting or spring return. Universal, clevis, or pivot mount. Rods vacuum hard chrome plated. Heads machined from square bar stock. Immediate delivery on 1", 2", and 3" strokes. Fractional or longer strokes available. 250 psi air; 1500 psi hydraulic.

SHEFFER PNEUMATICS HYDRAULICS

Write NOW, for Bulletin No. 1060

THE SHEFFER CORPORATION

Cincinnati 15, Ohio • Phone POpular 1-8227

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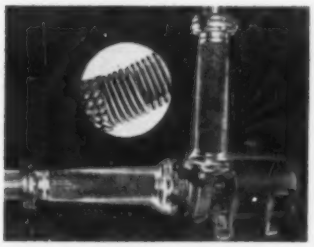
See Phone Book Yellow Pages

Circle **121** on Reader-Service Card

Threaded or flanged connections fit standard piping sizes. Helical corrugations offer less resistance to flow, distribute stresses along entire hose length.



Specifications: ¼" to 16" in stainless steel. ¼" to 8" in bronze and hot-dip galvanized steel. ¼" to 4" in Monel. For pressures to 1500 psi, temperatures to 1200 F.

Designation: H. A. P.—*Allied Metal Hose Co., Long Island City, N. Y.*

Circle **327** on Reader-Service Card

PANEL-MOUNTING QUICK-CONNECTS

At middle left in photo is MQC-3. Female 10-32 port at rear accommodates metal or flexible tube fit-

tings. Shown middle right, MQC-2 has female 10-32 thread at rear. When front portion of coupler is disconnected, valve in rear portion of unit stops flow. At bottom right is MQC-1. It has 10-32 male thread for clamp mounting or connection with miniature 12-port air manifold MAN-12. At top is a miniature air valve available 2, 3, and 4-way for pushbutton or cam follower operation.—*Clippard Instrument Laboratory, Cincinnati.*

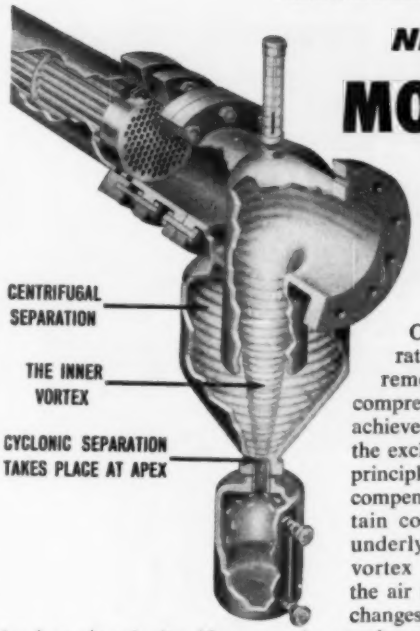
Circle **328** on Reader-Service Card

AIR FILTER

Integral self-draining mechanism. Drain valve, linkage, and float are mounted on removable plug, which screws into bottom of cast aluminum bowl. Float and linkage open drain valve when liquid in bowl reaches set height. Valve closes when float drops to low point during discharge. There is liquid in

Continued on next page

Circle **2** on Reader-Service Card



NEED BETTER

MOISTURE AND OIL REMOVAL?

(for your compressed air system)

Only the Adams CYCLONE Separator assures peak efficiency in the removal of oil and water from your compressed air system. Top operation is achieved from one-quarter to full load by the exclusive cyclone design. It is a proven principle of operation which automatically compensates for variation in load to maintain constant separating efficiency. The underlying feature is the inner cyclonic vortex formed within the unit itself by the air stream. The diameter of the vortex changes in proportion to variations in the load or air velocity. However, the angular air velocity, the RPMs, remain constant — and it is the angular velocity — the infinite changes of direction, which effect the separation of entrained particles at practically constant efficiency.

Remember, your aftercooler is only as effective as the separator which removes the condensed oil and water. Find out today how the Adams design can improve your oil and moisture removal efficiency. Write today for your copy of Bulletin 714.

R. P. ADAMS CO., INC. 249 EAST PARK DRIVE BUFFALO 17, NEW YORK

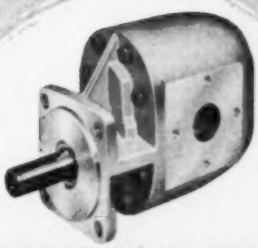
NEW **Maximum Performance** GEAR PUMP

Speeds to **2800 RPM**

Temperatures to **250° F** with min. **55 SSU**

Pressures to **2250 PSI** continuous

Flow rates to **60 GPM**



BERRY/DOWTY GPA3 Series

- Designed for operation at mobile equipment engine speeds
- Can be direct-connected, gear driven or belt driven
- Conforms to SAE standards

Berry HYDRAULICS
A DIVISION OF THE OLIVER TYRONE CORPORATION

MAIL FOR COMPLETE DATA

Berry Hydraulics
Corinth 1, Miss.

Name_____

Company_____

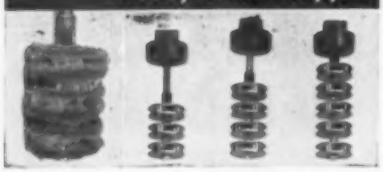
_____

_____

Circle **25** on Reader-Service Card

Circle **76** on Reader-Service Card

NEW MAGNETIC CLEANER for HYDRAULIC POWER UNITS the Kebby Tank-Trapper



★ Powerful Alnico V Magnets
★ Highest Active Area
★ Engineered for Power Concentration
★ Easy to Apply
★ Low Priced . . . Quick Delivery
★ No Moving Parts . . . No Maintenance

MEETS NEW J.I.C. HYDRAULIC STANDARDS

The Kebby Tank-Trapper is specifically designed to complete the protection of hydraulic systems against damage by iron particles worn off moving parts of various components. It picks up material missed by the filter and prevents premature filter loading. Expensive shut downs and service calls are drastically reduced. Write for Bulletin 1-500-59.

THE KEBBY COMPANY
2320 Custer Avenue Rockford, Illinois
Designers and Manufacturers of Magnetic Devices, Kebby Mite and Filtray Coolant Cleaners

bowl during and after drainage sequence. This water seal prevents air leakage through drain valve. Sump in plug to collect solids from bowl bottom.

Specifications: In ⅜" to 1" pipe sizes.

Designation: Crown Line—*Hannifin Co., div. Parker-Hannifin Corp., Des Plaines, Ill.*

Circle **329** on Reader-Service Card

PRESSURE SNUBBER

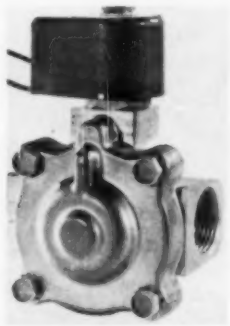
Protects pressure instruments against corrosion and plugging. Works equally well on systems with transient line surges. Upscale or downscale equilibrium readings in about 3 sec. If diaphragm ruptures, porous metal snubber prevents flow of corrosive materials into bourdon tube. If diaphragm seal and bourdon tube rupture, snubber restricts flow of pressure fluid into atmosphere to low rate. 2-piece housing assemblies protect gage systems from corrosive liquids. 3-piece assembly permits cleaning of diaphragm seal without disturbing liquid fill at downstream side.

Designation: Sealed System—*Chemiquip Co., New York.*

Circle **330** on Reader-Service Card

2-WAY SOLENOID VALVE

1" general purpose valve has forged brass body and bonnet. Operating parts are Buna N diaphragm, stainless steel diaphragm spring, and stainless steel solenoid core. Diaphragm can be removed without disturbing piping or electrical connections. Mounts in any position.



Specifications: For air, gas, water, light oil, and other non-corrosive liquids or gases at 5-125 psi. 5⅜" high, 3⅜" face-to-face. Requires 10.5 watts ac, or 10 watts dc. In any voltage to 550 vac, 250 vdc.
Designation: 8210A—*Automatic Switch Co., Florham Park, N. J.*

Circle **331** on Reader-Service Card

SAVE 82% ON 2000 PSI - HVY. DUTY HYDRAULIC CYLINDERS

We made a Fantabulous Buy of 10,000 Hydraulic Cylinders due to a Mobile Equipment Contract termination. These cylinders were engineered for Earth Moving Equipment, Presses, Tail Gates, Agricultural Equip., Industrial Machines, Lift Assemblies, etc.

Part No.	Bore	Stroke	Eye-to-Eye Length	Shaft Dia.	PRICE
H-70A	2½"	8⅜"	18¾"	⅞"	9.88
H-70B	2½"	10"	21¼"	1½"	10.88
H-70D	2½"	23¾"	35½"	1½"	18.88
H-70E	2½"	30"	40½"	1½"	24.88
H-70F	2½"	48½"	64⅜"	2"	29.88
H-70G	3½"	8"	19"	2"	17.88
H-70H	3½"	10¼"	21¼"	2"	19.88
H-70J	3½"	22½"	34¼"	2"	29.88
H-70K	3½"	30"	41"	1¾"	34.88
H-70L	3½"	43½"	55⅛"	1¾"	44.88
H-70M	3½"	47"	64½"	2"	49.88
H-70N	4"	22¼"	34⅜"	2"	36.88
H-70P	5"	43"	55⅛"	2¼"	79.88

SPECIAL! palley's

OUTPUT 0.6 CFM
2250 PSI CORNELIUS COMPRESSOR AND 115 V. MOTOR
99.50

Made up of a surplus Cornelius compressor combined with a new 1/2 HP, 115/220 V., 60 cycle AC electric motor . . . a mounting frame and built-in carrying handle. It's tested to 3,000 PSI. Will deliver 0.6 CFM. Ideal for use wherever high pressure air is desired . . . to fill air tanks, use in laboratory, etc. SAVE at our low price.

2500 PSI Cornelius COMPRESSOR – Surplus. Used but excellent condition. Has a built-in 1/3 HP, 27 V., DC motor. 42.50
1500 PSI Cornelius COMPRESSOR – Surplus. Used but Excellent cond. 32.50
1500 PSI Cornelius COMPRESSOR – Surplus in New condition 62.50

NEW

No. DPR-21-3000

SAVE ON HYDRAULIC "HI-LO" PRESSURE PUMPING UNITS

Ideal for use in applications where a fast approach to the work load is desired. Will deliver a total combined volume of both the pumps of 21 GPM . . . at pressures up to 500 PSI, then delivers output of the high pressure pump (4 GPM) at up to 3000 PSI. Both pumps are face mounted on a 7-1/2 HP, double-end, 220/440, 3-phase, 60 cycle AC motor. Entire pumping unit mounted on a 33 gallon reservoir (available without the reservoir). Overall size is 35" long x 18-1/2" wide x 18-1/2" high. Other Hi-Lo units available from 1500 PSI to 3000 PSI – WRITE for DETAILS!

palley/s Now 785.00

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LOS ANGELES 58, CALIF

TO ORDER: Send Check or M.O. – 1/2 deposit with C.O.D.s. Prices F.O.B. Los Angeles. All items shipped freight or postage collect.

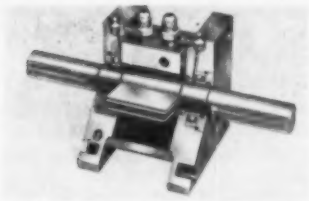
SPECIAL VALUE G-I AIR TANKS
Stainless steel. Tested to 400 PSI. Ideal for storage of air, chemicals, acids, etc. Has ¼" pipe ports. Size: 12-1/2" dia. x 24" long. NOW 11.95

Circle **101** on Reader-Service Card

ROTARY ACTUATOR

Instant full torque. Single vane (280-deg rotation) or double vane (100-deg rotation). Heads are machined from cold-drawn steel. Bodies of mechanical seamless steel tubing, honed to 10 micro-finish. Internal surfaces are hard-chrome plated. Precision ball bearings and roller bearings eliminate lapping action. Seals are backed up with

Teflon. One-piece vane and stator seals off corners for minimum bypass.

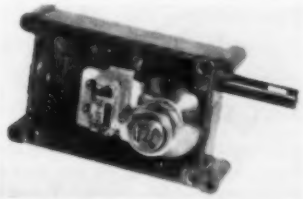


Specifications: Standard units produce torque from 100 to 430,000 in-lb. Heavy-duty line for 2000 psi. *—Roto-Tork Mfg. Co., St. Clair Shores, Mich.*

Circle **332** on Reader-Service Card

4-CIRCUIT ROTARY LIMIT SWITCH

Has four independently-adjustable cams. Each circut has a spdt switch.



Specifications: Glass-fiber, NEMA 1 enclosure is 3½" wide x 5½" long x 2½" high. Isolated contacts are rated at 5 amp, 115 and 250 vac, and 3 amp, 30 vdc. Cam arrangements from 25 to 335 deg in 20-deg steps. 15 standard gear ratios from 5:1 to 1000:1.*—Gemco Electric Co., Detroit.*

Circle **333** on Reader-Service Card

FILLER CAP

For hydraulic reservoir. Has 30-mesh brass wire screen. Twist locks cap into flange. Breather caps are

of the vented type of cadmium-plated steel. Flange of cadmium-plated steel.

Specifications: Screen is 3" deep, 1 5/16" dia.*—Lenz Co., Dayton.*

Circle **334** on Reader-Service Card

When COMPACTNESS is *IMPORTANT..*

SPECIFY *Pathon* HYDRAULIC CYLINDERS

1 The Pathon single screw thread attaching method gives you extra compactness, low stress concentration, and will withstand high greater shock load.

2 Adequate space between the bearing points gives you increased bearing and rod seal life, reduced power eating friction.

3 The head seal in all Pathon Cylinders is a true static seal, assuring you longer life in operation.

4 Pathon Cylinders have fewer parts, are easy to assemble, disassemble.

5 With Pathon Cylinders you have an extremely wide range of mounting types available to provide almost any mounting position you might want.

Write for further information today.

Pathon Hydraulic Cylinders are available in 1000—2000—3000 PSI and Low Pressure to 200 PSI

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MANUFACTURING COMPANY
3823 PACIFIC AVE., CINCINNATI 12, OHIO

FLUID OPERATED AND CONTROL EQUIPMENT

Circle **103** on Reader-Service Card

Circle **26** on Reader-Service Card

CHECK BM VALVES

Specify the very best!

ULTRA PRECISION

DISC TYPE—0.5 PSI CRACK AVAILABLE TO .06 PSI CRACK VERY LOW BACK PRESSURE

ONE PIECE BODY

DISC TYPE, 2—8 PSI CRACK ¼—⅜—½ F.P. BRASS HIGH PRESSURE—LEAKPROOF

ONE PIECE NIPPLE

DISC TYPE—2 PSI CRACK ¼—⅜—½— M.P. BRASS EXCELLENT FLOW—LEAKPROOF

SPECIALS

CUSTOM DESIGNED AND BUILT CHECK VALVES FOR HUNDREDS OF INDUSTRIES—QUANTITY PERMITTING

BODNAR & McDERMOTT MFG. CO. INC.

23 BEECHWOOD AVE. MT. VERNON, N. Y.

USEFUL LITERATURE

Continued from page 65

HYDRAULIC PUMP MOTORS

Built-in spline-coupling. Internal coupling splined to motor shaft. Conventional bore and keyway on pump side. Available for double and single-extension motors in dripproof construction. Motor with pump adapter has C-face end shield and sub-short shaft. Also available with flexible coupling. *General Electric Co., Schenectady.*

Circle **411** on Reader-Service Card

FILTER ELEMENT CLEANER

This ultrasonic equipment can clean flat and convoluted metal element surfaces. Pall-Cavitron HIPS (HyperIntense Proximal Scanning) cleaning system uses cavitation to clean filter elements. Produces maximum ultrasonic cleaning intensity which can be created in a liquid. Places a hyperintense field over small portion of element's surface. Filter element is rotated through field until entire surface is clean. Particles are flushed away continuously as they are loosened. Absolute-3-micron filter continuously removes particles from cleaning fluid. It takes less than 10 min. to clean most elements. Has means to verify pressure-drop and particle-removal efficiency of cleaned elements. *Pall Corp., Glen Cove, N. Y.*

Circle **412** on Reader-Service Card

AIR CONTROL VALVES

Inline 2, 3, and 4-way valves, and sub-base-mounted 4-way and 4-way 5-port valves. Air-operated, solenoid-pilot-operated. Valve selection tables, parts tables, cutaway drawings. Data on installation, maintenance, and conversion of valves to external pilot supply. *Hoffman-Odom Co., Dayton.*

Circle **413** on Reader-Service Card

LIMIT SWITCHES

For machine tools. Heavy-duty model L100W has 45 contact arrangements, 150 levers. Precision Model M has heavy-duty nylon latch mechanism. Bulletin 701

For high and low temperature needs in

SILICONE RUBBER
SEALS, PARTS, COMPONENTS

Go Goshen

PROFIT from GRC's advanced techniques in

COMPOUNDING
MOLDING
LATHE CUTTING
BONDING-TO-METAL

Learn for yourself why more and more design engineers "Go Goshen" for silicone rubber parts with properties like these:

- Resistance to temperature extremes of −80°F to +500°F.
- Resiliency over a range of −120°F to +600°F.
- Low compression set.
- Resistance to chemicals, oxidation, ozone, moisture, corrosion, shock, abrasion.
- Freedom from stain, odor, tackiness and toxicity.

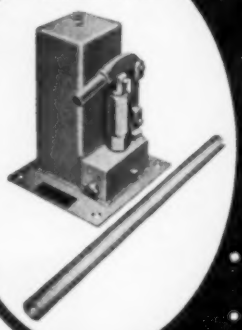
Write, wire or phone . . .

Goshen Rubber Co., INC.

1312-0 S. TENTH STREET GOSHEN, INDIANA

Circle **57** on Reader-Service Card

CATALOG NO. 160



Hand Hydraulic Pumps

- Single and Double Designs to 20,000 psi
- With or Without Reservoir

160 cubic inch reservoir with 8"x 8" base plate and 18" long handle.

Available with optional size pistons ⅜", ½", ¾", 1" and 1½".

We specialize in the manufacture of hand pump units which operate in temperatures from −65° F. to +160° F. and with any capacity reservoirs required. Pumps can be furnished on special order with custom seals to handle various aircraft types of fuels such as Pydraul, Skydrol, Oronite, etc.

The single pump with ½", ¾", 1" or 1½" piston is now available in stainless steel.

for additional information write:

WILLIAM S. PINE

hydraulic hand pumps for 1001 uses

1635 East 22nd St., Los Angeles 11, Calif.

Circle **105** on Reader-Service Card

shows operating data, ampere ratings, and dimensions. Detailed drawings of switches and levers. Cutaways show major features. Plug-in types also described. 4 pp. *R. B. Denison Mfg. Co., Bedford, Ohio.*

Circle **414** on Reader-Service Card

TFE-FLUOROCARBON SHAPES

Bulletin describes full line of Teflon stock shapes and fabricated parts. Chart of mechanical, thermal, electrical, and chemical properties. Application photos of rod, tubing, tape and sheet. Charts of dimensions. A section of Bulletin BR-4 covers Fluorosint, a TFE-fluorocarbon-base composition. *Polymer Corp. of Penna., Reading.*

Circle **415** on Reader-Service Card

PACKLESS VALVE

Resilient Neoprene diaphragm withstands deformation by trapped impurities. Provides tight shut-off, even during prolonged closed intervals. When valve is opened and particles are washed away, diaphragm resumes original configuration. For 500 psig, gas and liquid. Rated at 180 F. 10 in-lb closes it in dead-end service. In brass. ⅜" or ¼" NPT.—*George W. Dahl Co., Inc., Bristol, R. I.*

Circle **416** on Reader-Service Card

AIRLINE UNITS

Bulletin 0400-B1 has complete product listings of Crown filters, regulators, lubricators, and accessories. Includes new Self-Drain filters, pilot-controlled regulators, and matched combination units. Diagram of each unit. Dimensional drawings and tables. Parts identification section. 20 pp. *Valve & Crown Div., Hannifin Co., div. Parker-Hannifin Corp., Des Plaines, Ill.*

Circle **417** on Reader-Service Card

FLUID POWER ENGINEERING

Describes and illustrates solutions of engineering problems through fluid power. Covers electrohydraulic power and control systems for a seagoing hopper dredge, speed synchronization and control of extensible paper-machine section drives, drive synchronization for a seven-stage, completely-integrated glass jar packaging line, and how fluid power handles the rudder on a giant Great Lakes ship. Fluid Power news #13. *Oilgear Co., Milwaukee.*

Circle **418** on Reader-Service Card

MECHANICAL TUBING

Carbon steel tubing is electric-resistance welded. Bulletin T459 describes various types of tubing, including hydraulic fluid line and cylinder tubing. Covers quality-control procedures. Analysis chart. 8 pp.—*Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa.*

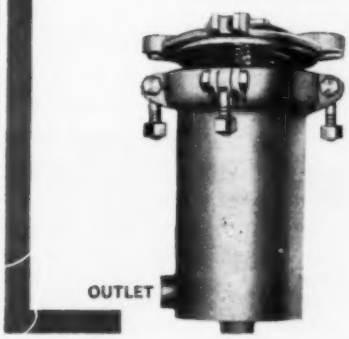
Circle **419** on Reader-Service Card

QUICK-CONNECT COUPLING

For plastic tubing. Slight hand pressure is enough to plug parts together. Cam action locks. To uncouple, press spring-loaded clip. Flow shuts off when disconnected. Connection far beyond burst strength of tubing. Only two moving parts. ⅜"-OD coupling weighs less than 3½ oz. ¼"-OD coupling weighs less than 2 oz. Couplings have Poly-Flo tube connections. They need only be hand-tight. Engineering Bulletin No. 3119.—*Imperial-Eastman Corp., Chicago.*

Circle **420** on Reader-Service Card

GET THE *ADDED PROTECTION* OF MAGNETIC SEPARATION WITH THIS BASKET-TYPE STRAINER



Nugent now manufactures a line of basket-type strainers offering the added protection of magnetic separation. Specially designed Alnico magnets establish a magnetic field through which the strained liquid must pass as a final stage before leaving the unit. Thus, minute ferrous particles are trapped and removed from the fluid stream.

If you have valuable engines or other equipment which demands top-notch lubrication protection, it will pay you to get the full story on the Nugent combination strainer-magnetic separator.

Write today . . . no obligation, of course.

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REPRESENTATIVES IN PRINCIPAL CITIES

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3432 CLEVELAND STREET, SKOKIE, ILLINOIS

OIL FILTERS • STRAINERS • TELESCOPIC OILERS
OILING AND FILTERING SYSTEMS • OILING DEVICES
SIGHT FEED VALVES • FLOW INDICATORS

Circle **96** on Reader-Service Card

POST SCRIPTS OF INDUSTRY

News about people, manufacturers and sales organizations

Hannifin names two chief engineers

Kurt W. Leibfritz has been appointed chief engineer, air valves, of Valve and Crown Div., Hannifin Co., div Parker-Hannifin Corp., Des Plaines, Ill. He was design engineer for air valves at Hannifin. James P. Fairbairn was named chief engineer, mobile hydraulic cylinders, for Hannifin's Power Cylinder Div. He was plant engineer for all Hannifin operations in Des Plaines.

Leibfritz

Fairbairn

American-Standard forms value analysis department

A. F. L. Anderson has been chosen to direct the new value analysis department of American-Standard, Industrial Division. He will analyze the efficiency of product designs and production methods. Anderson has been with the company since 1925. M. P. DeLisio was selected to work with Anderson. DeLisio's title is value analysis engineer.

Bendix transfers two

Bendix Filter Div., Bendix Corp., Madison Heights, Mich., has appointed Albert N. Beswick as eastern regional sales manager. He will maintain offices in Madison Heights. He was sales engineer for the Middle Atlantic states. Edward C. McFadden, formerly a sales engineer for Bendix Filter's West Coast branch, is now assigned to the Middle Atlantic states. His office is in Reading. Territory includes New York, New Jersey, Pennsylvania, Maryland, West Virginia, Delaware, and the Carolinas.

Lincoln opens branch office

Lincoln Supply Co., Pawtucket, R. I., opened a branch office in Hartford. Lincoln fluid power activities now cover all Connecticut.

Garlock appoints manager of marketing research

Edward J. Verity has been appointed manager of the Marketing Research Dept., Garlock, Inc., Palmyra, N. Y. He was vice president of Clayton Skiffs, Inc., subs. Lukens Steel Co., and general manager of the firm's plant in Toms River, N. J.

Aeroquip makes changes in sales

Bingham McClellan has been promoted to assistant OEM sales manager of Industrial Div., Aeroquip Corp., Jackson, Mich. He was an account executive in charge of accounts in the Cleveland territory. Replacing McClellan is Dan Collins, who was a service parts sales engineer in Wisconsin. Sherman Arnold replaces Collins. Robert Friedlund, who was a sales engineer in Ohio, has been made training director and special assistant to the general sales manager. Robert Rigali has taken Friedlund's territory. Rigali managed the division's industrial warehouse in Paterson, N. J.

Norman Engineering expands local service

Complete inventories of fluid power components will be stocked at all branches of Norman Engineering Co., Chicago. The move is to provide faster, more convenient service to customers in Illinois, Iowa, Wisconsin, and Minnesota. Rockford, Davenport, and Milwaukee will be stocked first. South Bend and Minneapolis will follow.

Hydraquip names Carlson sales manager

Hydraquip Corp., Houston, has appointed Russell Carlson sales manager. He will coordinate the company's advertising and public relations with the sales department. He was with the U. S. Army Engineers in Florida. Hydraquip distributes hydraulic and pneumatic equipment. The firm also has an office in Dallas.

Carlson

Bogert

Bogert to direct Wilkerson move

G. Keith Bogert is now manager of manufacturing of Wilkerson Corp., Englewood, Colorado. Under his direction, the company will move into its new plant under construction in Englewood. Bogert was superintendent of fabrication and processing at Ramo-Wooldridge Div.

Rothschild has new post at Jamesbury

New sales coordinator at Jamesbury Corp. is Edgar Rothschild. He will coordinate sales and manufacturing for the Worcester, Mass. company. He was in Jamesbury's contracts department, where he processed government orders for submarine and other military programs. Rothschild joined the firm in March, 1959.

Dieffenbach gets Pittsburgh territory

The Joyce-Cridland Co., Dayton, named Ferd Dieffenbach engineering distributor in the Pittsburgh area. He will handle the firm's industrial jacks and hydraulic equipment. He was with Duff-Norton Co., Pittsburgh, as assistant to the vice president-general manager.

Rando and Tutunjian move up at United Electric Controls

Robert Rando has been promoted to the new position of director of materials and production of United Electric Controls Co., Watertown, Mass. Advanced to purchasing agent is Myron S. Tutunjian, who was a purchasing expeditor. The firm makes temperature and pressure controls.

Moore names sales correspondent

Burton E. Snyder was made sales correspondent of Synflex Products Div., Samuel Moore & Co., Mantua, Ohio. He has been with the company for 15 years.

Dynex opens Cleveland office

Dynex, Inc., Pewaukee, Wisc., has opened an office at 5945 State Rd., Cleveland 34. David R. Clague is in charge.

Cameron and Robertson join Paul-Munroe Hydraulics

Paul-Munroe Hydraulics, Bell Gardens, Calif., has added two sales and systems engineers—Bob N. Cameron and Charles F. Robertson. They have more than ten years experience in hydraulic design, application, and sales.

Continued on next page

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- pressures to 5000 psi
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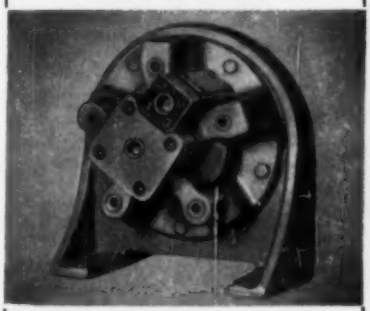

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POST SCRIPTS OF INDUSTRY

Fairbank to manage district for Conoflow

Conoflow Corp., Philadelphia, has named John A. Fairbank Philadelphia district manager. He joined Conoflow in 1957 as a sales engineer. He had been product manager of Robertshaw-Fulton Controls Co.

Ogle moves

Jack Ogle & Co. has moved to new, larger quarters at 861 Poplar Place, Seattle. Ogle distributes hydraulic and pneumatic equipment.

Davis to head valve & fittings firm

Craig L. Davis was elected president of Catawissa Valve & Fittings Co., Catawissa, Pa. He was chief engineer. Davis joined the company in 1946, as plant engineer.

Ford joins Kingston's Detroit sales staff

Kingston Products Corp., Kokomo, added Earl M. Ford to the staff of its Detroit sales office. He will work in automotive and agricultural hydraulics. He was with the hydraulic engineering departments of Vickers Inc., and Ford Tractor Div.

Ford

Finley

Webster adds sales engineer

John R. Finley has been added to the sales engineering staff of the Hydraulics Div., Webster Electric Co., Racine, Wisc. He will service Webster's distribution channels and develop additional outlets. Finley was a senior hydraulics engineer at Kearney & Trecker Corp.

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MAC has new general sales manager

Paul Ochenas was promoted to general sales manager of Mechanical Air Controls, Inc., Detroit. He was a sales engineer serving West Detroit.

American Engineering reorganizes divisions

American Engineering Co., Subs. United Industrial Corp., Philadelphia, has made its Marine and Hydraulic Div. into separate divisions.

Sales manager of the Hydraulic Div. is LeRoy J. Stoutenburg. He was with Rivett Lathe & Grinder, Boston, as development-project engineer and sales engineer.

Howell-Lanier changes name

The entire assets of Howell-Lanier Engineering Sales, Inc., Baltimore, were purchased by James T. Lanier. The company name is now Lanier Engineering Sales, Inc. Jack Howell is no longer with the company. There were no other personnel changes.

New distributors

Ritter Engineering Co., Pittsburgh, will handle power cylinders and air valves of Hannifin Co., div. Parker-Hannifin Corp., Des Plaines, Ill. *Haskel Engineering & Supply Co.*, Glendale, Calif., will distribute Hannifin cylinders, and industrial hose and hose fittings of Parker Fittings & Hose Div., Cleveland. Haskel has a branch in San Francisco. *Arkansas Equipment Co., Inc.*, Little Rock, will sell Parker hose and fittings.

Modern Equipment Co., Minneapolis, will distribute the Westinghouse unit type, and Le Roi stationary compressors of Le Roi Div., Westinghouse Air Brake Co., Sidney, Ohio.

Ditzen Engineering & Sales Co., Oakland, will represent Almo Manifold & Tool Co., Centerline, Mich., Manatrol Corp., Cleveland, and Owatonna Tool Co., Owatonna, Minn.

Knox, Inc., will handle the Vane and gear pumps of Hydreco Div., New York Air Brake Co., Kalamazoo. The Knox home office is in East Walpole, Mass.

Bill Maxwell, formerly a direct representative in the Midwest for Linear, Inc., Philadelphia, has formed *Maxwell Technical Sales*, Dallas. The firm will represent Linear in the Texas-Oklahoma and Wichita-Joplin areas. *Lamons Metal Gasket Co.*, Houston, will cover the Houston area for Linear. *Federal Industrial Sales Corp.* has been assigned the Indianapolis-Ft. Wayne area.

J. N. Fauver Co., Inc., Detroit, will engineer, sell, and service all fluid power products of Hydro-Line Mfg. Co., Rockford, Ill. Fauver has sales offices in Detroit, Flint, Grand Rapids, Kalamazoo, Toledo, Dayton, and Cincinnati.

Westinghouse Air Brake Co., Wilmerding, Pa., has named *Nix Supply Co.*, Oklahoma City, as a manufacturer's representative of its newly-acquired Petch line of air and hydraulic cylinders. Also named were *L. H. Flaherty Co.*, Grand Rapids, *Hydro-Mechanical Supply Co.*, Saginaw, Mich., *Anschuetz Machinery Co.*, Hamilton, Ohio, *H. B. Parke Co.*, Pittsburgh., and *Stewart-Hunt, Inc.*, Livingston, Mass.

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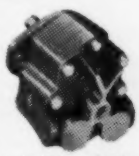

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Hydraulics & Pneumatics

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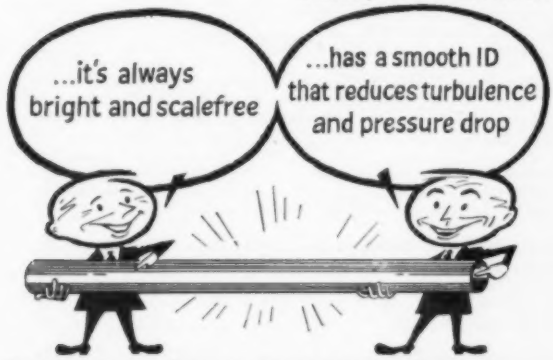

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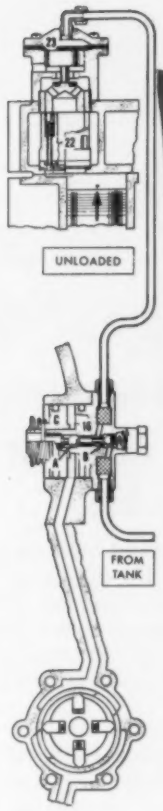

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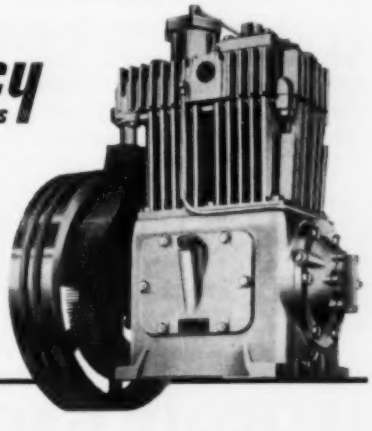
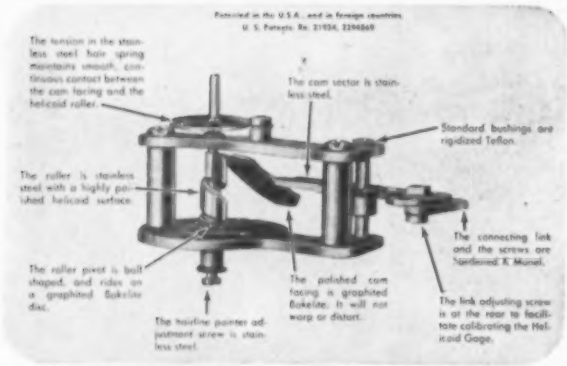


QUINCY COMPRESSOR CO., Quincy, Illinois
Makers of the World's Finest Air Compressors

Circle **106** on Reader-Service Card


Patented in the U.S.A. and in foreign countries
U. S. Patents: Re. 21934, 2290869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are Nonferrous "K" Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides *Sustained Accuracy* ...on the toughest jobs!

• Helicoid Gages have no gears, no teeth—wear is reduced to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Even when subjected to violent pressure pulsations or mechanical vibrations, Helicoid Gages *stay* accurate. Only Helicoid Gages provide *all* these advantages:

Sustained accuracy—Helicoid movements have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy. Conventional *geared* gages on the same test became useless after only 500,000 cycles.

Durability—Bourdon tubes won't stretch, leak or crack. Dial faces won't corrode or chip.

Wide selection—Gages are available for practically any application from tap water to acid. Gages include flanged and flangeless, round and square, in standard and flush-mounting models. Accessory equipment includes gage cocks, needle valves, siphons and snubbers.

NEW! Solid-Front Safe-T-Case Gage

This new Helicoid design diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming the back cover plate, which can then be replaced inexpensively.

Write for Catalog DH-65 for details on the complete line of Helicoid Gages

Distributed in Canada by Upton, Bradeen & James, Ltd.
Quebec, Montreal, Ottawa, Toronto, Hamilton, Windsor, Winnipeg, Edmonton, Vancouver

HELICOID GAGES

ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.
929-H Connecticut Ave., Bridgeport 2, Conn.

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HOKE

Flow Sheet

HOKE REPORTS ON FLUID CONTROL (1)

A VALVE NAMED "DESIRE"

With apologies to Tennessee Williams, we really have produced a Solenoid Valve line based on *your* desires. We surveyed all the solenoid valve users we could find to determine what *you* wanted. The result is Hoke's "User Designed" Series 90 and 95, two-way and three-way, direct-acting solenoid valve line.

Thanks to you, we have much to brag about. Here's what we have been saying about these new valves: lightest weight – smallest size – no-hum operation – lowest temperature rise–lowest power consumption – stainless steel plunger – silver AC shading coils – easiest installation – packless construction –360° rotatable housing – operates in any position.

We make them of forged brass or stainless steel, in ⅛" and ¼" NPT size or JIC tube ends. There's a variety of AC and DC voltages. Class "A" coils are standard, but Class "H" are also available for temperatures above 212°F. For those with high insurance rates, we can supply explosion proof coil housings.

Now that we've bragged a bit, we must also apologize for our premature enthusiasm. We were so excited about this product that we stirred up a hornet's nest of interest before we were ready to deliver in quantity. Shipments were slow at the start, but now we can have any reasonable quantity of these "desirable" solenoid valves "on-stream" in your plant when you want them.

There's only one way to get conclusive performance proof – buy a valve. Ask for Bulletin SV-1159.

FREE! A STEADY FLOW OF FACTS!

Further flow features, and interesting technical topics are carefully covered in Hoke's technical publication, the FLOW SHEET. It's free, but worth millions! To get the full benefit of our engineering and editorial efforts six times a year, mark your "X" in the proper box.

Hoke's Performance Guarantee – **Every Valve Leak-Tested!**

HOKE INCORPORATED
87 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

☐ Solenoid Valves ☐ Have a salesman call
☐ Flow Sheet ☐ Complete Catalog GC 960

NAME_____ TITLE_____
COMPANY_____
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CITY_____ STATE_____

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The most modern Reader Service Department in the publishing industry, staffed and trained to help readers. Automatic equipment processes your requests and shoots them on for fulfillment within hours after receipt. The materials you want get to you — fast.

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NEW PRODUCTS—brief descriptions of significant new products and materials.

PRODUCT APPLICATIONS—brief reports on successful applications of recently developed products and materials.

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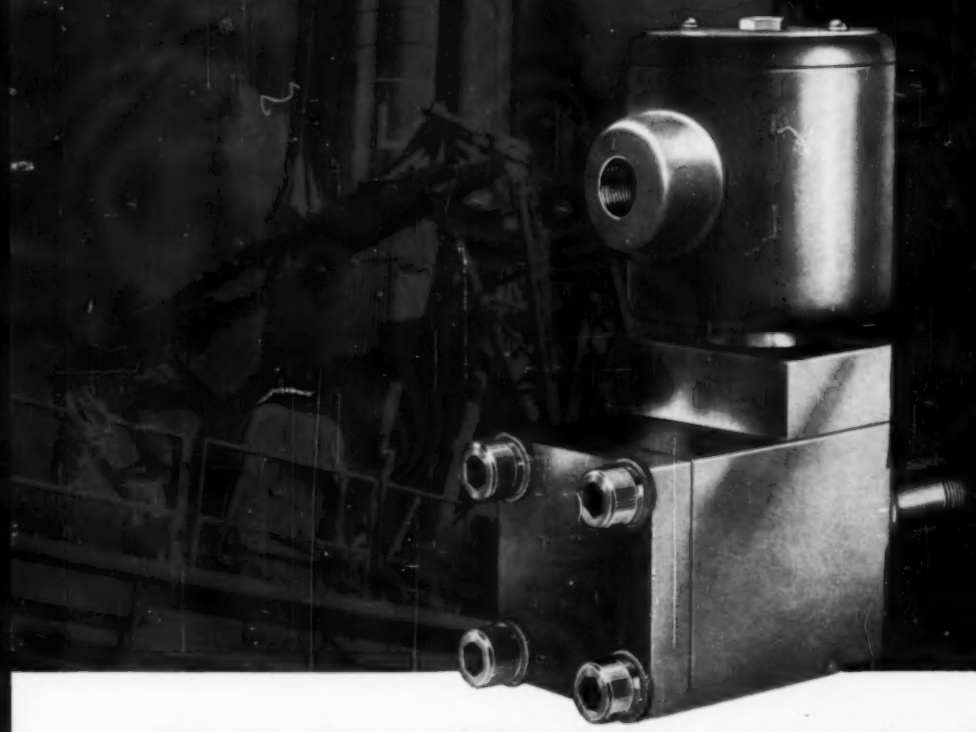
Reader Service Card—— HYDRAULICS & PNEUMATICS

ASCO SOLENOID VALVES ARE ENGINEERED TO MISSILE GROUND SUPPORT REQUIREMENTS

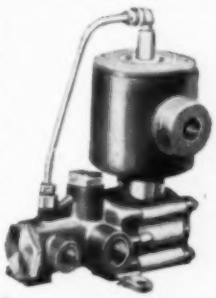


Tight Shut-Off at Pressures to 3000 PSI, Temperatures to Minus 350°F.

ASCO now brings you a family of solenoid valves, specially designed for missile applications with tough environmental or operational requirements. Two, three and four way valves are available with standard, explosion-proof or watertight solenoids; sizes range from ⅜" through 2½". Fluids handled include air, liquid oxygen, helium and nitrogen (liquid and gaseous). Valves can be supplied with continuous duty coil windings for 24 volts D-C, and for any other commercial voltages required. All types are packless (hermetically sealed), providing tight shut-off, with no external leakage to atmosphere.

Two Way Valves . . . normally open or normally closed, easily handle fluids at pressures to 3000 psi, temperatures to -350° F. Valves are stainless steel with teflon discs; most sizes are available with AN connections (Main Illustration-Bulletin 8223X).

Three and Four Way Valves . . . are suitable for piloting cylinder operated valves. Three way valves are also utilized for controlling single acting cylinders, and diaphragms; four way valves are used for controlling double acting cylinders. Unique poppet type seats and discs assure tight seating at pressures to 750 psi, temperatures to -65° F. Valve shown below (Bulletin 8344X) is suitable for 4 way applications, or may be used for 3 way installations by plugging one cylinder connection.



Proposals are submitted upon receipt of specifications—or an ASCO Engineer can help you in solving your ground support valving problems.

For additional information on ASCO Solenoid Valves for Missiles, write for Publication V5056.

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